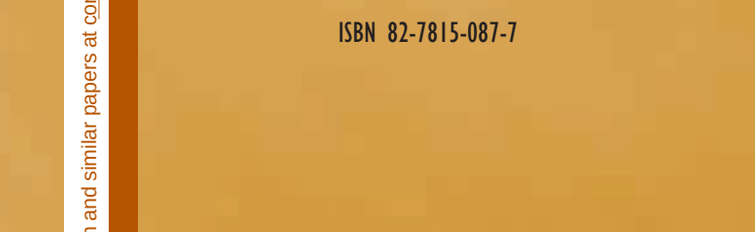


hed by the Centre for International Health, University of Bergen, Noway.
Design and print by Creato AS, Bergen, Norway.

ISBN 82-7815-087-7

www.creato.no • T13111B-10-03

Perinatal mortality and anaemia in pregnancy in rural northern Tanzania - Sven Gudmund Hinderaker

Perinatal mortality and anaemia in pregnancy in rural northern Tanzania

Sven Gudmund Hinderaker

Centre for International Health
Univerity of Bergen
Bergen, Norway, 2003

Perinatal mortality and anaemia in pregnancy in rural northern Tanzania

Sven Gudmund Hinderaker

Centre for International Health

University of Bergen

Bergen, Norway, 2003

Author: Sven Gudmund Hinderaker

Title: Perinatal mortality and anaemia in pregnancy in rural northern Tanzania

Doctoral thesis submitted in partial fulfilment of the requirements for the degree of *Doctor Medicinae* at the University of Bergen, 2003.

Cover photographs:

Front: Auscultation – Sven Gudmund Hinderaker
Blood and urine examinations – Sven Gudmund Hinderaker
Mother and child – Bjørg Evjen Olsen

Back: Weighing pregnant women – Sven Gudmund Hinderaker
Three other pictures by Bjørg Evjen Olsen

ISBN 82–7815–087–7

Published by the Centre for International Health, University of Bergen, Norway.
Printed by Creato AS, Bergen, Norway.

To my dear mother.
You have twice lost a baby in the perinatal period. You understand the pain of the families I met who had experienced a perinatal death.

Table of contents

List of figures

List of tables

List of maps

Abbreviations

AC	Arm circumference
AIDS	Acquired immunodeficiency syndrome
ANC	Antenatal care
AOR	Adjusted odds ratio, “risk”
BS	Thick blood slide
CI	Confidence interval
CBR	Crude birth rate
CDC	Centers for disease control and prevention
COSTECH	Commission for science and technology, Tanzania
CRP	C-reactive protein
CSSC	Christian social services commission
DDH	Designated district hospital
DH	District hospital
DMO	District medical officer
ELCT	Evangelical Lutheran church of Tanzania
END	Early neonatal deaths
FIGO	The international federation of gynecology and obstetrics
Hb	Hemoglobin
Hct	Hematocrit
HELLP	Syndrome with hemolysis, elevated liver enzymes, low platelets
HIV	Human immunodeficiency virus
HLH	Haydom Lutheran hospital
HSR	Health sector reform
ICD 10	International classification of diseases, tenth revision
ICPD	International conference on population and development
LD	Lactate dehydrogenase
LND	Late neonatal deaths
MCH	Mother- and child health
MMR	Maternal mortality ratio
OR	Odds ratio, “risk”
PMR	Perinatal mortality rate
RHP	Reproductive health project in Mbulu/Hanang
SB	Stillborn
STD	Sexually transmitted diseases
Tfsat	Transferrin saturation
UNFPA	United Nations Population Fund
UNICEF	United Nations Children’s Fund
UTI	Urinary tract infections
VDRL	Venereal diseases research laboratory test, unspecific syphilis test
VHF	Very high frequency
WB	World Bank
WBC	White blood cells
WHO	World Health Organization

List of original papers

Paper I: **Perinatal mortality in rural Tanzania**. Hinderaker SG, Olsen BE, Bergsjø P, Lie RT, Gasheka P and Kvåle G. *Journal of Health, Population and Nutrition* 2003; 21(1):8-17.

Paper II: **Avoidable stillbirths and neonatal deaths in rural Tanzania**. Hinderaker SG, Olsen BE, Bergsjø P, Lie RT, Gasheka P, Havnen J, and Kvåle G. *BJOG: an International Journal of Obstetrics and Gynaecology* 2003; 110(6).

Paper III: **Anemia in pregnancy in the highlands of Tanzania**. Hinderaker SG, Olsen BE, Bergsjø P, Lie RT, Gasheka P and Kvåle G. *Acta Obstetricia et Gynecologica Scandinavica* 2001; 80:18-26.

Paper IV: **Anemia in pregnancy in rural Tanzania: Associations with micronutrients status and infections**. Hinderaker SG, Olsen BE, Lie RT, Bergsjø PB, Gasheka P, Bondevik GT, Ulvik, RJ, Kvåle G. *European Journal of Clinical Nutrition* 2002; 56(3)**:**192-199.

Acknowledgements

I was working at the Haydom Lutheran Hospital in Tanzania at the time when I was granted a scholarship funded by the Norwegian Research Council. The project was conducted at the Centre for International Health, University of Bergen. The field work was based at Haydom Lutheran Hospital, which provided an excellent foundation and network for collecting the data. I wish to express sincere gratitude to the institutions and persons that facilitated the research: the Commission for science and technology, the Regional Development Director in Arusha, the Regional Medical Officer in Arusha, the District Commissioners in Mbulu and Hanang, the District Medical Officers in Mbulu and Hanang, and the District MCH coordinators in Mbulu and Hanang.

I am sincerely grateful to all the participants in the study, who willingly shared their knowledge, and without whose consent this study would not be possible. It is my sincere hope that the results of the study may benefit them and their families.

To my classmate, colleague, and co-author Bjørg Evjen Olsen, I owe very much for productive visions and energetic management capability. You have my deepest respect for your boundless integrity, your ceaseless concern for the disadvantaged and opposition to injustice, as well as your great sense of humour and disarming self-irony.

I am indebted and sincerely grateful to my main supervisor, professor Gunnar Kvåle, who patiently led me through the project with advice and generous support. I am grateful to professor Per Bergsjø and professor Rolv Terje Lie who served as co-supervisors with important contributions throughout the study. My gratitude also goes to professor Rune Ulvik who was co-supervisor for the anaemia-study and who made it possible to do the laboratory analyses. Benedikte Eskeland helped with the biochemical analyses. Further, I would like to thank Clinical Officer Peter Gasheka for invaluable working capacity and helpful ideas. I would also like to thank the co-authors Gunnar Bondevik for useful ideas from his own field experience, and Jakob Havnen for fruitful discussions and useful advice in neonatology. Ole Bjørn Rekdal and Astrid Blystad are also gratefully acknowledged for invaluable input on the cultural aspect of the problems encountered. Professor Rune Nilsen, who was the Director of the CIH at the time I started, initiated my interest for research during his visit in Haydom. His

visions and generosity are inspiring for all the students. Professor Odd Mørkve has been a good support, sharing office and interests.

Generous help and support was given by the administrative staff at the Centre for International Health: Terje Halvorsen, Jon Wigum Dahl, Solfrid Hornell, Ragnhild Hauge, Borgny Kvalnes Lavik, Grethe-Marie Eilertsen, Solveig Ullaland, Marit Hegland, Helge Opedal, Kai Günther Brandt, Martha Lopez, Eldbjørg Sanden Søvik, and the many civil workers through the years.

I also want to thank Nils Gunnar Songstad for good company as he was a frequent visitor in Haydom as a Peace Corps Volunteer, and later as a student of Bergen University. I have greatly appreciated the fellowship with former and present students of the CIH, among them (alphabetically) Bjarne Robberstad, Bjørn Blomberg, Eliud Wandwalo, Elton Kisanga, Emmanuel Makundi, Godfrey S. Mfinanga, Ismael Abbas Darout, Jane Heuch, Jean-Claude Mwanza, Lado Lako Loro, Karen-Marie Moland, Melkiory Masatu, Method Kazaura, Mihaela Roxana-Cimpan, Ram Krishna, Reem Rahil Khazen, Sabai Phyu, Tehmina Mustafa, Tor Strand, and Tsigeweini Tessema,.

I am indebted to our project staff in the Reproductive Health Project in Haydom. Sincere thanks are extended to Christina Domel, Elirehema Simjan, Emmanuel Karengi, Fanueli Simjan, Firidiana Timoteo, Happiness Petro, Hayte Samo, Helena Bayo, Helena Massay, Herman Malleyeck, James Gitonge, Justin Masuja, Kinto Arusha, Maria Sikay, Mariamu Gitonge, Neema Gissos, Nuruana Petro, Paulina Domel, Paulina Maghang, Petro Gasheka, Rehema Matfari, Samweli Duxo, Selina Gasheka, Thomas Gidaros, and Veronika Danieli.

I am grateful to the Mbulu Diocese of the Evangelical Lutheran Church of Tanzania (ELCT) for allowing research to be done at their hospital. Indispensible help and support was given by the staff and administration at Haydom Lutheran Hospital. The tireless Medical Director Ole Halgrim Evjen Olsen, Matron Selina Sanka, and the Medical Secretary dr.Naftali Naman, gave valuable support in all aspects of the field work. The staff at the MCH department led by Bertha Sulle, graciously received us and assisted in the data collection. Mr. Zakaria Musa, who knew me since before I started in primary school, gave daily practical help in my flat.

The Department of the Laboratory at the hospital meticulously performed important work for the project; the late Emmanueli Dahaye, Elisha Lukas, Reuben Ami, and Deborah Bariye. The friendly staff at the maternity ward, the garage, and the medical history section of the hospital were supportive and contributed whenever requested. Dr. Isaack Malleyeck, dr. Emmanuel Mayega, and Herman Malleyeck kindly helped collecting data from the medical records at the hospital.

I am grateful to the enthusiastic and supportive leaders in the study area helping us with data collection, at all administrative levels, division, ward, village, sub-village, ten-cell leaders. Special thanks go to the leaders and citizens of the Endamasakt village, sub-villages Gaghata, Endamudayga and Ginyawiri, with whom special friendship developed through the household survey.

Thank you, Herman Malleyeck, Emanuel Mighay, Peter Gasheka, Hayte Samo, Samweli Gideoni and Elibariki Gideoni for sharing with me your stories, memories and ideas, thereby opening fascinating new worlds to me.

For motivation and encouragement, I am greatly indebted to Rune Mjølhus, Ingunn Fjose and Øystein Evjen Olsen.

I am deeply grateful to my late father and my mother patiently supporting me. You provided me four siblings, priceless companions to whom I am sincerely grateful, Jorunn, Stein Olav, Bjørn and Hans David, and their spouses and children.

Summary

The aim was to estimate the perinatal mortality rate, to study potential determinants and causes of perinatal and neonatal deaths, and their avoidability in a rural area of Tanzania. Further, we studied the prevalence of anaemia in pregnancy and the determinants of anaemia in pregnancy.

Attendants of the existing Mother- and child-health (MCH) clinics in the area run by the Haydom Lutheran Hospital were registered on their first antenatal visit and followed up one month after birth. Those who disappeared were traced to their home. In the cohort of 3618 women, some women were not possible to find (106) and 3512 were followed up and identified. Spontaneous abortion was reported in 42 cases, 3359 had a living baby, 53 had a still birth, 42 had an early neonatal death and 16 had a late neonatal death.

We studied the causes of stillbirths and neonatal deaths and their avoidability in the cohort. To secure a more complete picture, we also included deaths identified in a household study of 1259 homes in the same area: 6 stillbirths, 8 early neonatal deaths and 7 late neonatal deaths. The MCH attendants (n=3836) were studied cross-sectionally for prevalence and determinants of anaemia in pregnancy. Also, based on their hemoglobin (Hb) value, we selected 153 controls and 159 cases of anaemia with varying severity “nested” within the cohort, for a study to evaluate micronutrients and infections as determinants of anaemia.

The perinatal mortality rate (PMR) in the cohort was 27/1000 births, 56% were stillborn and 44% were early neonatal deaths. There was increased risk of perinatal death among babies with low birth weight and among women with a positive s-VDRL (Venereal Disease Research Laboratory). Women who had previously lost a baby and very lean women were also at higher risk.

Still births and neonatal deaths were often related to infection (39%), asphyxia (24%) or immaturity (15%). Among these deaths, 15% were estimated to be probably avoidable and a further 10% possibly avoidable, under the prevailing circumstances. Among the potentially avoidable stillborns and neonatal deaths, a patient-oriented avoidable factor was present in 51%, and a provider-oriented factor in 65%. Very few of the women were aware of their risk factors.

The mean Hb of the pregnant women was 12.1 g/dl, and 4.5% of them had Hb below 9.0 g/dl. The mean Hb was higher among persons living at higher altitude and at higher maternal age, and was lower during the malaria-season, and among women with malaria parasitaemia.

Anaemia among pregnant women was associated with iron deficiency, folate deficiency, and vitamin A deficiency. It was also associated with elevated *C-reactive protein* (likely infection) and elevated *Lactate dehydrogenase* (hemolysis, likely due to malaria infection). It was also associated with general signs of undernourishment (a small arm circumference).

The estimated PMR in this setting was lower than what has been found for other areas of Tanzania. This might be attributed to a well functioning health system in the area. The MCH had a high attendance of pregnant women, and although the referral to higher level was low, the existing MCH familiarized the women with the health system and made it more natural to be admitted to hospital if needed for delivery. Still, at least a quarter of the deaths in the study could have been avoided under the prevailing circumstances. The MCH should make sure that messages are understood and referrals accomplished.

Anaemia in pregnancy was less prevalent than in other areas of Tanzania. Common risk factors of anaemia were deficiencies of iron, folate, vitamin A, and infections, including malaria.

1 Introduction

1.1 REPRODUCTIVE HEALTH

In many societies, to marry and have children is the very meaning of life. Human reproduction gives social status, produces a work force and represents investment in the future, as well as securing succession of the family. The healthy outcome of a pregnancy is often regarded as a gracious gift, since the hazards are often observed and feared. Various traditional methods are used to secure a favourable outcome, e.g. traditional medicine, prayers, and witchcraft. Childlessness may be interpreted as a divine punishment, whereas many children may be a sign of blessing.

Box 1. Definition of reproductive health.

The following definition was endorsed by 165 countries at the International Conference on Population and Development (ICPD) in Cairo, 1994:

Reproductive health is a state of complete physical, mental and social well-being and not merely the absence of disease or infirmity, in all matters relating to the reproductive system and to its functions and processes. Reproductive health therefore implies that people are able to have a satisfying and safe sex life and that they have the capability to reproduce and the freedom to decide if, when and how often to do so. Implicit in this last condition is the right of men and women to be informed and to have access to safe, effective, affordable and acceptable methods of family planning of their choice, as well as other methods of their choice for regulation of fertility which are not against the law, and the right of access to appropriate health-care services that will enable women to go safely through pregnancy and childbirth and provide couples with the best chance of having a healthy infant.

In line with the above definition of reproductive health, reproductive health care is defined as the constellation of methods, techniques and services that contribute to reproductive health and well-being by preventing and solving reproductive health problems. It also includes sexual health.

Source: ICPD [1], § 7.2

Reproductive health outlines health related aspects of human reproduction and addresses the reproductive processes, functions and systems at all stages of life. The definition stated in Box 1 is useful for high-income countries, because it encompasses all health-related aspects of human reproduction. However, in a poor setting, the main focus is on the survival of the pregnant women and their offspring. Other matters of reproductive health are naturally given

lower priority than survival. Globally, the major hazards threatening the life of pregnant and delivering women and their offspring are hemorrhage (25%), sepsis (15%), abortions (13%), eclampsia (12%), obstructed labour (8%), other direct causes (8%), and indirect maternal deaths (20%) [2]. Infection with Human Immunodeficiency Virus (HIV), malaria and severe anaemia may lead to indirect maternal deaths. According to estimates of the World Health Organization (WHO), half a million women die every year from these causes and many more suffer severe morbidity from their consequences [2]. The death of a mother severely jeopardises the survival chances of her offspring [3]. For the neonates, the major hazards in a global perspective are infection related (42%), asphyxia related (21%), immaturity related (10%), and congenital malformations (11%) [4].

The global strategy to secure healthy reproductive outcomes is based on human rights and equity and rests on four pillars: 1) care for the women during pregnancy and childbirth; 2) care for the newborn; 3) control of sexually transmitted diseases; and 4) family planning [5].

1.2 GLOBAL STRATEGIES TO ACHIEVE HEALTHY REPRODUCTION

In 19th century Europe, the maternal and perinatal/neonatal mortality rates were similar to the rates in many developing countries today. During the last decades of that century, Sweden managed to reduce maternal mortality substantially by focusing on skilled birth attendants at community level, whereas the countries insisting on deliveries being conducted by specialists only (most of Europe, USA), lagged behind [6]. The improving socio-economic conditions were essential for the reduction of infant mortality, but seemed not to affect maternal mortality. However, the interventions in Sweden to reduce maternal outcome also seemed to reduce perinatal mortality [7], suggesting that maternal mortality is closer related to perinatal mortality than to infant mortality.

The core of the antenatal care programs was developed in the early 20th century. The pre-defined screening of pregnant women by a series of examinations at different stages of gestation was designed to detect conditions that threatened the pregnancy. This should in theory enable health personnel to treat and monitor these complications to secure a better outcome, and was later called the “risk approach”. The contents and timing were most often not scientifically evaluated [8, 9]. Most developing countries inherited the European health systems during colonial times, and health care provision, including the antenatal care, was usually hospital or facility based.

During the 1970s, the Primary Health Care concept with preventive health services and community involvement was emphasised, as pronounced in the Alma Ata declaration of 1978 [10]. It led to a shift from facility based to decentralised, community based health care provision. Mother-and child health (MCH) care was one of the essential components of the strategy.

The efforts had little impact on the maternal mortality. As a consequence, the Safe Motherhood Initiative was launched at the Safe Motherhood Conference in Nairobi in 1987, through a collaboration between several agencies: the World Health Organization, United Nations Population Fund (UNFPA), the World Bank, the United Nations Children's Fund (UNICEF), the International Federation of Gynecology and Obstetrics (FIGO), and others [11]. Their ambitious initial goals were to reduce the maternal mortality ratio to 50% of the 1990 level within 2000, and to reduce the perinatal and neonatal mortality rate by 30-40% within 2000 [5]. The strategy aimed at *equitable access* to care and provision of services at the *lowest capable* level in the health system. With evidence-based practices, it helped mobilising resources and drew attention to the human rights dimensions of maternal and neonatal mortality. However, the Safe Motherhood Initiative failed to achieve its initial goals, for several reasons. The "risk approach" depended heavily on a health care system that was often neglected or even illusory. Most of the complications of pregnancy and childbirth occurred unexpectedly among the low-risk women, because even though at lower risk, their total number was much higher. This has led to the acknowledgement that *all* pregnancies should be regarded as "at risk". Some of the lessons from the Safe Motherhood Initiative were summarised in a meeting in 1997 [12].

An evidence-based strategy, the Mother-Baby Package, was developed by the Safe Motherhood Programme in WHO [5]. The basic main focus of health interventions are family planning, antenatal care, safe delivery, and essential obstetric care (Box 2). It is being updated as scientific evidence appears.

The International Conference on Population and Development in Cairo in 1994 focused on reproductive rights, particularly the rights of women [13]. Important issues were gender equity, poverty eradication and sustainable development, and access to health care. It also called for

male participation in a key role for bringing about gender equality and responsible parenthood.

Box 2. The objectives of the Mother-Baby Package

1. Promote family planning methods	8. Reduce maternal deaths due to hemorrhage
2. Provide basic maternity care to all women	9. Reduce maternal deaths due to obstructed labour
3. Promote exclusive breastfeeding	10. Reduce maternal deaths due to sepsis
4. Reduce anaemia in pregnancy	11. Eliminate neonatal tetanus
5. Reduce STD in pregnant women	12. Reduce neonatal deaths due to asphyxia
6. Reduce maternal deaths due to complications of abortions	13. Reduce neonatal deaths due to hypothermia
7. Reduce maternal deaths due to eclampsia	14. Reduce ophtalmia neonatorum

Source: WHO [5]

For a long time, antenatal care was a ritual with little scientific (but all the more emotional) justification [8, 9]. Archie Cochrane wrote in 1972; "By some curious chance, antenatal care has escaped the critical assessment to which most screening procedures have been subjected." A randomised trial comparing the current standard routine antenatal care visits with fewer – but more focused – visits was recently published. The study involved several countries, enrolled more than 10.000 participants in each group, and showed no significant differences in pregnancy outcome for mothers and offspring [14].

During the last four decades, there has been a remarkable reduction in infant mortality rates, mostly among the post-neonatal infants (1-12 months of age). Recent improvements in infant mortality is largely due to immunization and control of diarrhoeal diseases, whereas stillbirths and neonatal deaths has not decreased at the same rate [15]. The reduced infant mortality rate has been least impressive in Sub-Saharan Africa, and has recently levelled off, partly as a result of the AIDS pandemic (Table 1). However, maternal mortality has not declined in most places [2], and perinatal mortality is still high. This reflects the difficulties in *implementation* of the Safe Motherhood interventions, and also the effects of the severe AIDS epidemic. Recent improvements in infant mortality are largely due to immunization and control of diarrhoeal diseases, whereas stillbirths and neonatal deaths have not decreased at the same rate [15].

Table 1. Infant mortality rate trends in the world, in deaths per 1000 live births.

Region	1960	1970	1980	1990	1995	2000
World	126	96	79	64	60	57
Industrialised countries	31	20	12	8	6	6
Developing countries	141	108	88	70	66	63
Sub-Saharan Africa	153	136	119	111	110	108
Tanzania	142	129	106	102	103	104

Source: UNICEF [16]

1.2.1 Perinatal and neonatal mortality

The definitions of perinatal and neonatal period is given in Box 3 and illustrated in Figure 1. The older (1977) definition of the International Federation of Gynecology and Obstetrics (FIGO) used 28 weeks of gestations as the start of the perinatal period instead of 22 weeks, and may be more appropriate for low-income countries [17]. We therefore used this definition in the current study. Perinatal deaths include stillbirths and early neonatal deaths. The perinatal mortality *rate* is the number of perinatal deaths divided by the total number of *births* in the same period. The neonatal mortality *rate* is the number of neonatal deaths divided by the number of *live born babies* in the same period.

Box 3. Definitions of neonatal and perinatal death

Definitions according to ICD-10, 1992 [18]

The perinatal period commences at the 22 completed weeks (154 days) of gestation (the time when the birth weight is normally 500g), and ends seven completed days after birth.

The neonatal period commences at birth and ends 28 completed days after birth. Neonatal deaths (deaths among live births during the first 28 completed days of life) may be subdivided into early neonatal deaths, occurring during the first seven days of life, and late neonatal deaths, occurring after the seventh day but before 28 completed days of life.

Definition according to FIGO and WHO, 1977 [17]:

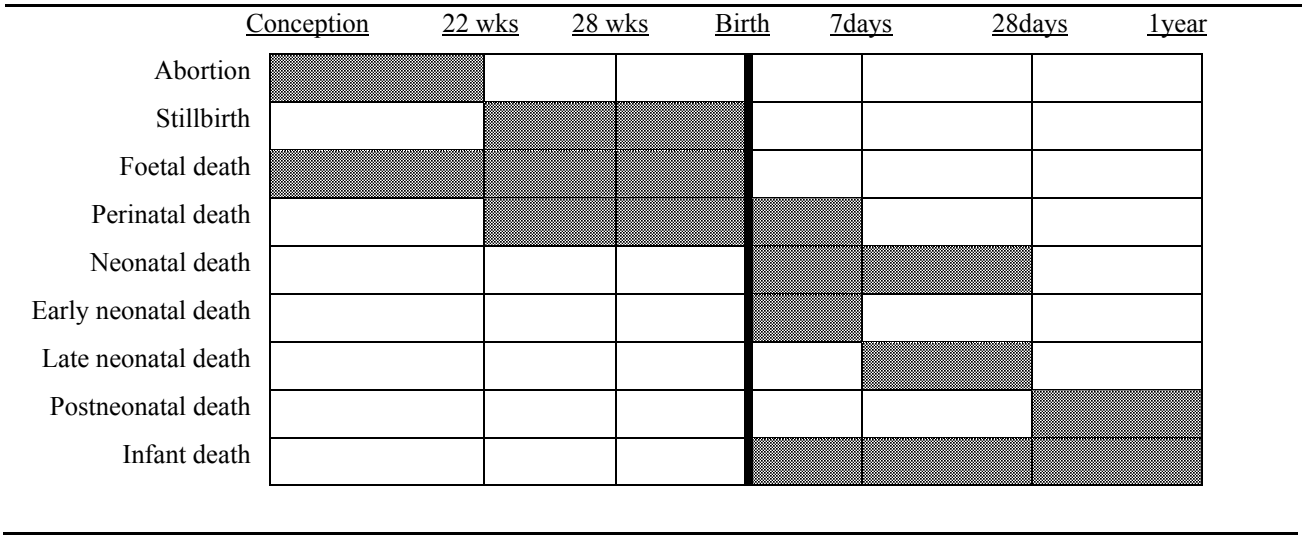
The perinatal period is the one extending from the gestational age at which the fetus gains the weight of 1000 g (equivalent to 28 completed weeks of gestation) to the end of the seventh completed day (168 completed hours) of life.

Early neonatal death is death of a live-born infant during the first seven days (168 hours) of life.

Late neonatal death is the death of a live-born infant after 7 completed days, but before 28 completed days of life.

Childbirth is a dangerous event in spite of being a physiological process. The period around birth is a time in life with a very high risk of death, and for all the major causes of neonatal death, the first days of life has the highest risk of death.

Figure 1. Illustration of terminology applied to fatal events in the first year of life.



The World Health Report 2000 estimated that perinatal conditions took 2.4 million lives in 1999, representing 4.2% of the deaths in the world [19]. Projections to 2020 have suggested a reduction to 0.9 million deaths [20]. Neonatal conditions took almost 4 million lives in 1993[4], and globally the neonatal and perinatal mortality rate is not decreasing as rapidly as infant mortality.

Most perinatal and neonatal deaths are due to either asphyxia related conditions, immaturity-related conditions, infections, or congenital malformations. Some deaths are directly associated with labour, and may also be the result of poor management of the delivery or a suboptimal health system. Other determinants of perinatal and neonatal deaths are associated with small and preterm babies. Preterm babies have an immature immune system, rendering them more susceptible to infections. They are less capable of enduring the mechanical stress of labour, they are less resistant to hypothermia, and their lungs may be immature. All these factors put preterm babies at a much higher risk of perinatal and neonatal death. The frequency distribution of causes of perinatal death is very different in low-income-countries and high-income-countries. In the high-income countries, the easily treated conditions are rare, whereas malformations and immaturity related conditions predominate. In low-income

settings, the more easily treated conditions like infections and asphyxia related conditions are more commonplace, and may also indicate problems in the health system.

The mother represents the living environment for the foetus, and many maternal factors can lead to small and preterm babies. Systemic infections and urinary tract infections have been associated with preterm delivery and low birth weight [21], and so have nutritional deficiencies [22] and anaemia [23, 24]. For live-born babies, the death of the mother represents a 'handicap' which makes them four to six times more likely to die [25].

1.2.1.1 Possible interventions to reduce perinatal and neonatal mortality.

No single intervention can prevent perinatal and neonatal deaths. Infant mortality rates have decreased with improving socio-economic development, particularly the postneonatal deaths. Perinatal deaths are more associated with problems during pregnancy and childbirth. Often interventions towards perinatal problems coincide with interventions to improve the maternal health. The quality and access to health services are immensely important. Some evidence-based potential **interventions** are listed below [5].

1. Before conception:

- increased access and utilization of acceptable family planning methods
- supplementation of folate to prevent neural tube defects
- management of STDs

2. During pregnancy:

- improved antenatal care, with detection and management of risk factors and complications like pre-eclampsia, anaemia, malaria, and urinary tract infections (UTI)
- tetanus toxoid immunization
- improve readiness for delivery and prepare for unexpected complications
- practical arrangements regarding delivery place, assistant, where to seek emergency obstetric services in case of serious complications, money and transport, whom to take care of the home in case of complications
- involvement of husbands in the preparations, as they are often decision makers and holder of the resources of the household.

3. During delivery:

- the involvement of a skilled birth attendant
- securing clean delivery and avoiding infections of mother and new-born
- detecting complications, particularly bleedings, and being ready to take immediate action

4. Neonatal period:

- rapidly securing respiration and heartbeat of the baby
- avoiding hypothermia
- recommend exclusive breastfeeding
- prevent infections

5. General:

- securing rights and equity for women and children
- improving equitable access to health care that should be culture sensitive
- involve men (often decision makers) to achieve equity and responsible parenthood
- prevention of sexually transmitted diseases (STD) and human immunodeficiency virus (HIV) among both women and men

1.2.2 Anaemia in pregnancy

Anaemia is regarded as a major risk factor for an unfavourable outcome of pregnancy. Severe anaemia is contributing to 5-16% of maternal deaths[26-29], and some papers indicate that anaemia in combination with hemorrhage is responsible for 17-46% of maternal deaths [30]. Anaemia in pregnancy has also been associated with low birth weight [31-38], preterm birth [39-41] and perinatal mortality [38, 42, 43]. The association with preterm birth is not firmly established [42, 44], and the evidence for an association between iron-deficiency anaemia and poor pregnancy outcome may be insufficient [45]. A high Hb is also associated with poor pregnancy outcome [34, 38, 46, 47]. The physiological backgrounds for the adverse outcomes are different for the mother and the child. For the mother, severe anaemia may cause high output cardiac failure, or she may have less blood reserves to withstand hemorrhage during childbirth. For the foetus, maternal anaemia may give a sub-optimal nutritional environment, leading to growth retardation or preterm birth. These again put the child at risk of perinatal and neonatal death. Even though an increased risk of poor pregnancy outcomes among anaemic women might be

very small, anaemia may have a considerable impact when very prevalent. The management of anaemia in pregnancy aims at prevention and treatment of its underlying causes, and is an important part of antenatal service [48].

There is no level of Hb that can confidently define all the anaemic from the non-anaemic persons, since the frequency distribution of Hb in both of these groups overlap considerably. According to the World Health Organization, the definition of anaemia in pregnancy is a hemoglobin concentration (Hb) less than 110 g/l, and severe anaemia if Hb less than 70 g/l (Box 4). Globally, there may be more than 2,000 million people with Hb below the WHO norms [49]. It is a particularly common condition among pregnant women, especially in developing countries, where more than half of them may be anaemic [26].

Box 4. WHO definitions of low hemoglobin (Hb) and hematocrit (Hct) in pregnancy [26].

	Hb	Hct
Anaemia	< 110 g/l*	<35%
Moderate anaemia	70-109 g/l	24-34%
Severe anaemia	40-69 g/l	13-23%
Very severe anaemia	< 40 g/l	<13%

* 105 g/l in second trimester.

1.2.2.1 Causes of anaemia in pregnancy

Several factors may contribute to anaemia during a pregnancy. The **physiological** increase in plasma volume is larger than the increase in red cell mass, and leads to hemodilution and decreasing Hb concentration until 7-8 months of gestation. Then Hb increases towards term [50, 51]. Hb below 120 g/l is regarded as anaemia in non-pregnant women, whereas among pregnant women Hb below 110 g/l is considered as anaemia (Box 4). Some people use gestational-age-dependent cut-offs for Hb, where the cut-off in 2nd trimester is 105 g/l. The absence of this hemodilution has long been associated with poor pregnancy outcome [31, 38, 46] and hypertensive disorders of pregnancy [37, 47].

The principal **pathological** conditions leading to anaemia may be related to nutrition, bone marrow suppression, and hemolysis or blood loss.

Iron requirements increase during pregnancy: in addition to the obligatory iron loss (0.2 g), 0.5 g is needed to increase maternal hemoglobin and 0.3 g is needed for the foetus.

Approximately 30 mg is needed for the placenta. The total requirement during pregnancy may be one gram [52, 53]. Iron depletion affects most of the non-supplemented pregnant women, and may lead to anaemia when there is insufficient iron to produce hemoglobin. Iron deficiency is regarded as the most common cause of anaemia in pregnancy worldwide. In a study done in Dar es Salaam, Tanzania, iron deficiency was observed in 86% of anaemic pregnant women [54].

Vitamin A plays an important role in cell growth and differentiation, in addition to the well-known function in the retina. It has also been associated with anaemia, and seems to have additive effect with iron supplementation [55]. During infections, excretion of vitamin A in urine increases and s-vitamin A levels may decrease [56]. The magnitude of vitamin A deficiency in pregnancy in Tanzania was largely unknown at the start of our study.

Folate is needed for cell multiplication, and the requirements increase during pregnancy because of increased erythropoiesis and a growing foetus. A typical folate deficiency may lead to megaloblastic anaemia. In addition to its effect on the blood, folate deficiency has been associated with neural tube defects [57] and low birth weight [58]. According to the guidelines for antenatal care clinics (ANC) in Tanzania, folic acid is given free of charge to the pregnant women. This may be good for the women, but is too late at booking to prevent neural crest anomalies. A study from Dar es Salaam found macrocytosis (interpreted as mainly folate deficiency in this setting) in less than 4% of anaemic pregnant women [54].

Cobalamin is usually not considered as a common cause of anaemia in pregnancy, as the body stores are large. Dietary cobalamin deficiency can be seen in strict vegetarians (non-existent in the study area). Insufficient absorption of cobalamin (pernicious anaemia) is usually a disease of older people. This vitamin is involved in the DNA synthesis of cell multiplication, and deficiency can lead to megaloblastic anaemia. Good figures of cobalamin deficiency among Tanzanian pregnant women were not available at the start of this research.

Although single micronutrient deficiencies may cause anaemia, severe anaemia is often caused by several factors acting together [54, 59]. The composition of such a multi-micronutrient supplementation has been suggested, for testing in effectiveness studies [60]. A recent, large study in Nepal showed no better result on birth weight with multi-micronutrients supplementation than with iron and folic acid supplementation [61].

Aplastic anaemia rarely occurs in pregnancy, but **bone marrow suppression** can occur in systemic infections and malaria [62], or as an adverse reaction to drugs (e.g. chloramphenicol).

Hemolytic diseases during pregnancy may be genetic (sickle cell disease, thalassaemia, G6PD-deficency), which are common in certain geographical areas, or acquired (HELLP syndrome). Hemolysis can also be due to malaria infections [63, 64]. From working in the local hospital, it was evident that patients with sickle cell disease were usually children from the neighbouring district of the study area, whereas among the major ethnic groups of the study area it was rare. The frequency of G6PD deficiency in Tanzania is not well described in the literature.

Blood loss in pregnancy may occur as antepartum or postpartum hemorrhage, and may be life threatening within short time. A recent study done in Morogoro, Tanzania, attributed to 17% of maternal deaths to postpartum hemorrhage [65].

Infections may lead to anaemia in several ways. The inflammation induces a sequestration of iron into the reticulo-endothelial system as storage iron. This may be seen as a physiological response impeding the growth of the invading iron-dependent bacteria, but will also lead to a moderate anaemia because of inhibited (iron-insufficient) erythropoiesis. Infections can also lead to a reduction in red cell survival and bone marrow suppression. HIV infection often produces anaemia, and is quite common in urban areas like Arusha and Dar es Salaam [54]. The frequency of HIV infection among pregnant women in this area was low, 0.3% [66] .

Malaria infection is the major cause of anaemia among pregnant women in many areas of Africa [54, 67-69], and anaemia may develop through several mechanisms [70]. First, malaria may lead to massive destruction of red cells and hemolysis. Malaria plasmodia invade erythrocytes, mature and multiply through various stages, which in the end lead to bursting of the invaded erythrocytes and the release of new parasites ready to repeat the cycle. Secondly, malaria disease may also suppress the bone marrow and in this way contribute to anaemia [62]. A third mechanism for malaria to cause anaemia is hyper-splenism. Chronic malaria often leads to enlargement of the spleen, and if the enlargement is gross, hemolysis may be a result of the hyper-active spleen. Malaria may lead to severe anaemia, and if the anaemia develops slowly, Hb values as low as 30 g/l may be observed among women who are walking on foot.

Malaria seems to affect primigravidae more than multigravidae [71]. A study from Zanzibar found signs of malarial infection in 56.5% of primigravidae and 44.7% of multigravidae [72].

Intestinal parasites are an important cause of anaemia in many developing countries. Persons accommodating blood-sucking hookworms may suffer from considerable occult intestinal blood loss and subsequent anaemia [73]. In a study from Dar es Salaam, it was shown that 44% of severely anaemic and 17% of moderately anaemic pregnant women had intestinal parasites [54]. In the northern highlands of Tanzania, the frequency of intestinal parasitosis was lower than in the coastal areas.

1.2.2.2 Interventions against anaemia in pregnancy

Interventions and tools proven to alleviate anaemia in developing countries, include supplementation of micronutrients, like iron supplementation [74], folate supplementation [57], and vitamin A supplementation [55]. Several ways of avoiding the consequences of malaria in pregnancy has been proven effective, like malaria prophylaxis [71], treatment of presumed malaria with sulphadoxin-pyrimetamin [75], and use of impregnated bed nets [76]. In a public health perspective, the major obstacles to effective control of anaemia are patient's acceptance and operational constraints [77, 78].

1.3 THE REPRODUCTIVE HEALTH PROJECT IN MBULU AND HANANG DISTRICTS

The Reproductive Health Project in Mbulu and Hanang districts started as an initiative to study various aspects of pregnancy and childbirth in two rural districts in northern Tanzania, Mbulu and Hanang. Two social anthropologists with background in nursing, were studying cultural aspects in the area [79-81, 82], and had shared their concerns with the staff of the local rural hospital, Haydom Lutheran Hospital (HLH), where I was working. As a clinician at the hospital, I had also observed the complications of pregnancy and childbirth, and experienced successes and failures in the management. A colleague with deep roots in the area, Dr. Bjørg Evjen Olsen, was also intrigued by the health problems associated with reproduction and how to improve the outcome of pregnancy. We were challenged to study reproductive health in the area, both mortality and conditions commonly encountered among pregnant women in the area: urinary tract infections, malaria and anaemia. We were both involved in all aspects of the study, and the Centre for International Health, University of Bergen, provided the academic foundation. The existing epidemiological knowledge in the area and the existing

network and facilities at Haydom Lutheran Hospital created a useful site for research activities in the surrounding communities.

A large cohort of antenatal women was selected in order to study the perinatal and neonatal mortality (Papers I and II), and demographic determinants of anaemia (Paper III). Within this cohort, a "nested" case-control study was selected to examine micronutrients and infections as potential determinants of anaemia in pregnancy (paper IV). The maternal hazards of pregnancy in this setting were studied in a collaborating project by Dr. Bjørg Evjen Olsen, focusing on the maternal outcome of pregnancy and on urinary tract infections in pregnancy [83-87].

2 Aims and objectives

The current study is part of a larger study of maternal and child health in the area. Previously a PhD thesis entitled "Motherhood – A hazardous endeavour" [83] described findings related to maternal death, and to urinary tract infections. The current study is primarily based on the same population.

Aims

The aim of the project was to study the outcome of pregnancy. We wanted to study known and potential determinants of perinatal and neonatal mortality in the area, and in particular anaemia in pregnancy. The project intended to provide a basis for measures to improve the health of mothers and children.

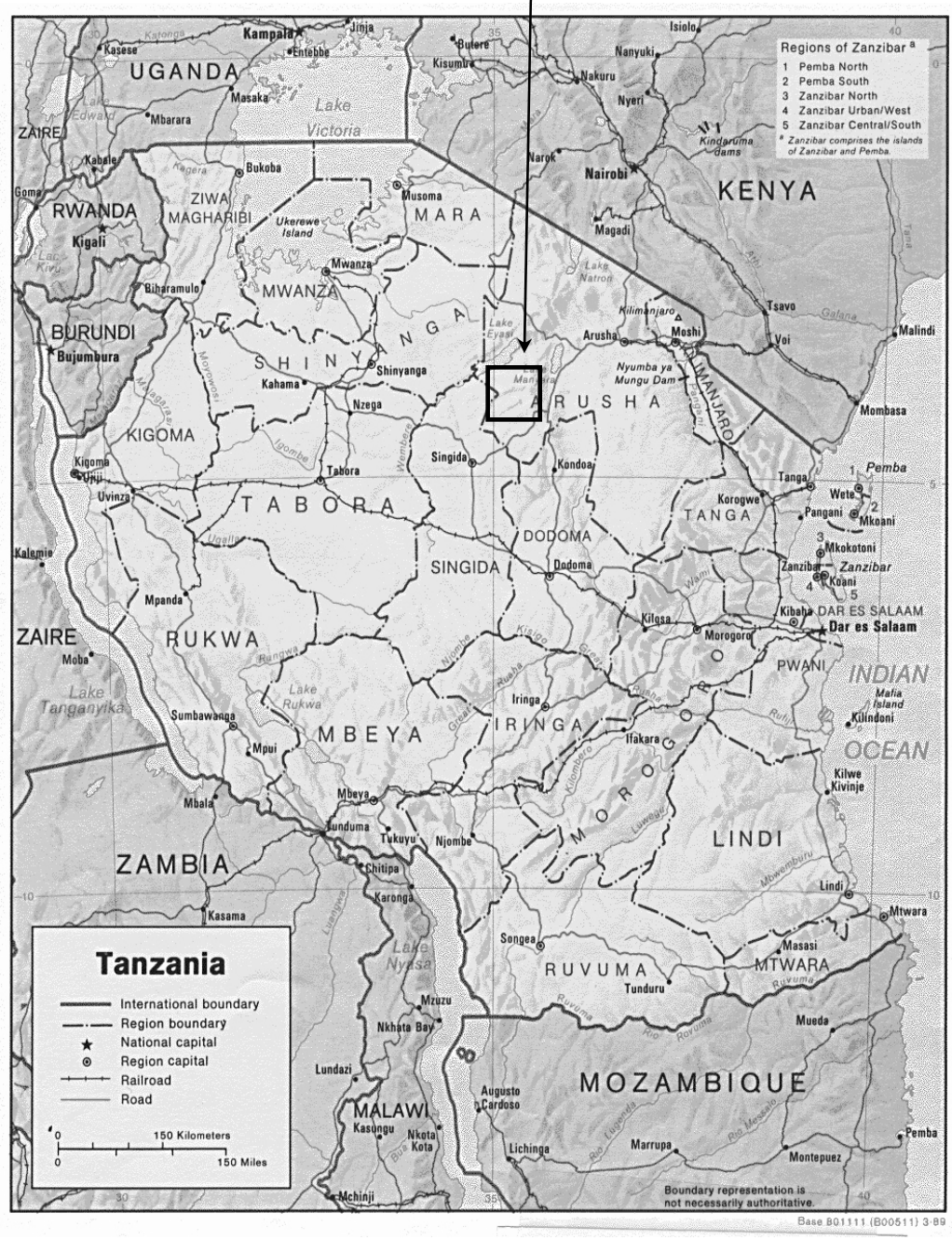
Objectives

The specific objectives of the study were to:

1. Estimate the perinatal mortality rate in Mbulu and Hanang districts.
2. Study known and potential determinants of perinatal deaths in Mbulu and Hanang, including anaemia, malaria, and urinary tract infections.
3. Study the causes of stillbirths and neonatal deaths in Mbulu and Hanang districts.
4. Study the avoidability of stillbirths and neonatal deaths in Mbulu and Hanang.
5. Study the prevalence of anaemia in pregnancy in Mbulu and Hanang districts in Tanzania.
6. Study known and potential determinants of anaemia in pregnancy.
7. Study the associations between anaemia and iron-status, folate status, cobalamin status and vitamin A status.

Map of the United Republic of Tanzania

Study area



3 Description of study area

3.1 TANZANIA

Tanzania had a long history as a colony, first under German rule (1884-1920), then British (1920-1961), before it became independent in 1961. In 1964, Tanganyika united with Zanzibar to form the United Republic of Tanzania. Many Sub-Saharan African countries have been marred with civil war, but Tanzania has been remarkably peaceful in this regard. The Arusha declaration of 1967 stated the "villagization" policy, an African socialism based on collective agricultural venture running along traditional African lines. It aimed at self-reliance and providing essential services to the people, notably education but also health services. The economic policy failed to develop according to the expectations. Approximately 60% of the population have less than 2USD a day, and survive by agriculture [88]. A poverty reduction policy is being implemented with the assistance of the World Bank [89]. In 1995 the first multi-party election took place. Still, the ruling party *Chama cha mapinduzi* (CCM, Swahili: "Revolution party") got 60% of the votes and won, reflecting the deep-rooted extensive influence of the party.

Tanzania (map p.16) is a large country in East Africa covering 945.000 km^2, almost twice as large as France. According to the census in 2002, the population is approximately 34 million, and the population growth rate is 2.9% [90]. The World Health Report 2001 indicates that half of the population is below 15 years of age, and only 4% are over 60 years [91]. The infant mortality rate is estimated to be 85 per 1000 live births, and life expectancy at birth is 45 years. Most of the population live in rural areas (67%), and 56% have access to an improved water source. 24% of the population over 15 years are illiterate. There are more than 120 ethnic groups with different languages, but most people speak the official language Swahili, and many speak English, the second official language. According to official figures, agricultural export, including coffee, cotton, tea, tobacco, cashewnuts and sisal, accounted for 56% of merchandise exports (1996-99). Minerals also represent major export revenues, and are growing. The booming tourist industry relying on the extraordinary wildlife environment in Tanzania, creates ten times as great revenue as the minerals [92].

3.1.1 Health system in Tanzania

The health expenditure in the years 1992-98 was 3% of GDP, divided between public (1.3%) and private (1.8%) [93]. This amounts to 8 USD per capita (15 USD purchasing power parity, PPP). The health service structure is governed by the Ministry of Health in Tanzania, but the services are provided by government, voluntary agencies, and private companies. The health "pyramid" consists of several levels of care. According to the Ministry of Health figures, in the year 2000 there were more than 5000 village health workers, approximately 3500 dispensaries, 480 health centres, and 180 hospitals [88].

The *Village Health Service* is the lowest level of health care delivery in the country. They essentially provide preventive services that can be offered in homes. Usually, each village health post has two village health workers chosen by the village government amongst the villagers and given a short training. The *dispensary services* represent the second level in the health services pyramid. A dispensary caters for 6,000 to 10,000 people and supervises all the village health posts in its ward. There were approximately 4000 registered dispensaries in Tanzania (approximately 2500 government owned). A dispensary may be staffed by a nurse/midwife and a rural medical aide, and usually has a labour room and provide essential obstetric services. A *Health Centre* is expected to cater for 50,000 people, which is approximately the population of one administrative division (tarafa). There were about 500 registered health centres in Tanzania (400 owned by government). Health centres are staffed by Clinical Officers, Nurses and Midwives. The health centre usually has beds and delivery facilities, including vacuum extraction and intravenous infusion, but not blood transfusion and surgical facilities. Each district is supposed to have a *district hospital (DH)***,** headed by the District Medical Officer, who is an assistant medical officer or a medical doctor by training. In some districts, a voluntary agency hospital is designated to be a district hospital (DDH), and get subventions from the Government to contract terms. In 2000, there were 55 government DH, 13 DDH, and 86 other hospitals in Tanzania; the HLH in the study area is one of latter. The 17 *Regional Hospitals* in Tanzania offer similar services like the district hospitals, but in addition give specialist services that are not provided at district hospitals. The four *Consultant Hospitals* constitute the top of the health pyramid, and are large teaching hospitals with specialist services [88, 94].

Non-profit voluntary agencies play an important role in the institutional health services in Tanzania, representing more than 50% of the hospitals, including some teaching hospitals and

a university hospital. The largest contributors are the Catholic Church, the Evangelical Lutheran Church, and the Anglican Church. All the hospitals receive staff- and bed-grant from the government, underscoring their place in the health system, and they report to the Ministry of Health through the appropriate channels. These voluntary agencies were organised in a body called Christian Social Services Commission (CSSC), negotiating with the donors and the government.

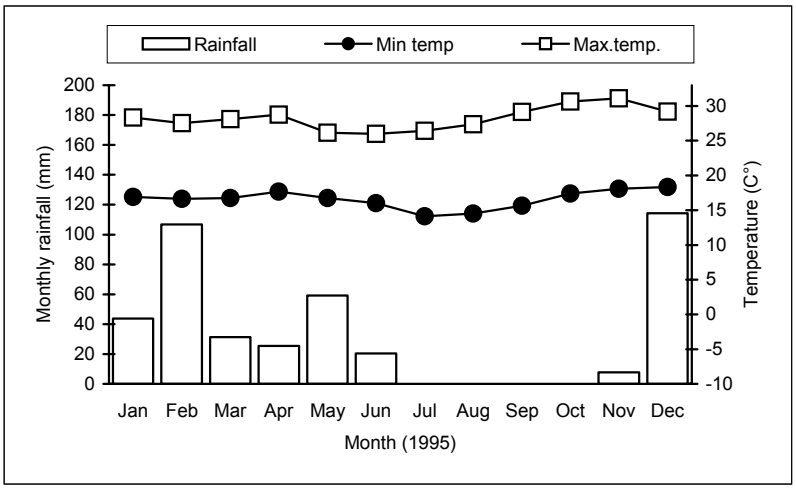
In line with the economic reforms advocated by the World Bank and IMF, the health sector is currently undergoing reforms (HSR). The aim is to improve the performance of the health sector, by emphasising efficiency, equity and quality of the services. The strategies are decentralization, program integration, self contributions, focus on essential services packages, sector-wide approaches, civil service reform, insurance coverage, and engaging the private sector [95].

One of the problems in many sectors in Tanzania is low motivation that may be related low salaries. Often a medical doctor can earn more money in business than by working as a doctor. There is a shortage of medical doctors in rural Tanzania. Understandably, the cities provide more opportunities for them, and many Tanzanian doctors have moved abroad to neighbouring countries. A system of meriting at rural posts may improve coverage.

3.2 MBULU AND HANANG DISTRICTS AND THE STUDY AREA

The study was conducted in Dongobesh division of Mbulu district, and Basotu division of Hanang districts in the northern part of Tanzania, in Arusha region 200 km south of the famous Ngorongoro crater. The Great Rift Valley cuts through the area, giving rise to a varied topography. Most of the area lies on a plateau 1600-2200 meters above sea level, while the Yaeda valley is at approximately 1300 m. The highest areas have rainforest. Most of the uninhabited area is covered with savannah grass, bushes, and acacia trees. The extinct volcano Mt. Hanang (3390m) is among the highest mountains in Tanzania and a landmark in the study area. The climate is temperate, with mean temperature between 20-30 ºC. During the dry season, there is usually no rain. There is usually a short prelude of rains in November-December, and the long rains usually lasts from January till May (Fig.2). The average annual rainfall is 600-800 mm. According to MARA map, the climate is suitable for hypo- and meso-endemic malaria transmission [96].

Figure 2. Monthly rainfall and temperatures in Haydom, 1995.



3.2.1 Infrastructure

The infrastructure is not strong in the area. There are no tarmac roads, and the dirt roads may be difficult to pass in the rainy season. The main roads are maintained by the district council when the budget allows, and feeder roads in the study area are constructed by the Haydom Lutheran Hospital with technical support from the district. The collaboration came as an initiative from the hospital to improve access and availability of patient transport, and is supported by external donors. The rainy season often creates problems of transport because of mud and erosion.

Several bus services exist, linking Haydom town with Mbulu, Arusha, Katesh and Singida. The buses depart once daily, and schedules are unpredictable. Few people in the study area have a vehicle, but cars exist in Haydom, Dongobesh, and Basotu. A bicycle is widely used by men, while only a few women use one. Transport of pregnant women to clinics and to hospital is often on the carrier of a bicycle. Walking is the most common way of travelling.

In the study area, there were no telephone lines in 1995, and few houses and institutions had power via the national electricity network. The closest telephone was in Mbulu town at that time. However, very-high-frequency (VHF) radio contact exists, linking distant villages together with Mbulu town and with the HLH. Most of the VHF radios are owned by the HLH and placed in the houses of entrusted persons. If the operator is temporarily away, another person in the house will operate it. The radios are robust and running on solar panel-charged

batteries. The radios provide communication facilities for villagers to call the ambulance at the hospital. The radio is available day and night at the HLH. Recently, telephones have become more common.

3.2.2 Cultural characteristics

According to the 1988 census and a growth rate of 3.8%, Basotu and Dongobesh divisions (the study area) had approximately 143 000 inhabitants in 1995 during the data collection. Most of the people in the study area belong to the ethnic groups of Iraqw and Datoga. Two socio-anthropologists, Ole Bjørn Rekdal and Astrid Blystad have studied their culture, and many issues are depicted from their work [79-82, 97-103].

These two ethnic groups have different origins. The Iraqw are speaking a Cushitic language, whereas the Datoga belong to the Nilotic-speaking group (like the Masai). There is extensive intermarriage between the two ethnic groups, and the real identity is often ambiguous. Some Datoga would state they are Datoga in one situation and Iraqw in another situation [99]. Some names are similar as well. The leather skirt of women is often the best way of identifying women living in a traditional Datoga way. The Iraqw are agropastoralists, and the Datoga originally pastoralists, but are more and more adapting to agriculture. For both ethnic groups, the main commodity of wealth is cattle. In a household survey conducted in the study area, the number of cows in a household was reported to be 7-8 cows for both ethnic groups. Less than 2% of the households had more than 30 cows, and 15% had no cattle. 10% had an acre of field or less, and less than 3% of households had more than 10 acres of field. Average acreage was between 3 and 4 acres per household. However, all these numbers are according to their own statements, which are always somewhat underreporting.

In addition to the Iraqw and the Datoga, other ethnic groups exist in smaller numbers, notably the Iramba and Nyaturu who dominate in the Singida District south of the study area. There is very limited intermarriage between these ethnic groups and the Iraqw and the Datoga. A few other groups are also scarcely represented (Chagga, Pare), often being civil servants or business people from other parts of the country.

There is considerable cultural overlap between the two major ethnic groups in the area, the Iraqw and the Datoga. However, a higher proportion of Datoga live in a "traditional" way,

whereas more Iraqw adapt to a more "modern" village life. There is for example a highly visible manifestation of traditional culture among datoga, including female dress and decoration. Such aspects of "traditional" culture are to a considerable degree stigmatized among the ones who have moved towards a more "modern" way of life. This fact may influence the extent to which datoga women attend the antenatal clinics, and could therefore introduce some selection bias.

Procreation is a central matter in both ethnic groups, and both are traditionally polygamous. Having children is associated with status, security, creation of a workforce, and the meaning of life itself, resulting in a commitment to family growth [102]. A man without offspring is often disregarded, and even his funeral may not be honoured properly. Childless women may get both emotional and social stress, and may end up in divorce. Infertility has a very strong stigma, and is used as a derogatory and offensive term. Concepts of “stuck pregnancies” are common, and may indicate several medical conditions, such as early spontaneous abortions, missed abortions, and irregular menstruation. After such events, a woman may still regard herself as pregnant, but the foetus “went back”. Later, it may start growing again "spontaneously" and some women may therefore state a pregnancy duration of 10 years.

The purpose of modern family planning is often not well accepted. It is often misunderstood or not understood at all, as a high number of children is not a threat, but is regarded as a blessing. Not the least due to the cost of living, some people are beginning to use modern family planning devices, particularly injections.

The Datoga are intensely preoccupied with the protection of fertility [81]. Successful birth giving is not taken for granted, and pregnancy and infancy are often protected by many complicated customs. The pregnant woman will try to avoid conflicts with anybody in the household, including the husband. A husband's beating of his pregnant wife is unacceptable, unlike for non-pregnant women. It is regarded as a sin against fertility and womanhood at large, and may result in penalty or even a curse or excommunication if he is remorseless [102]. The pregnant woman should avoid rivers and lakes, the dwelling place of evil spirits. She must also be careful with strangers, as they may have a bad influence on the foetus, and therefore large crowds of people should be avoided [81]. This could certainly be a problem for antenatal attendance, which fortunately seems to be increasingly accepted. During pregnancy, the woman is often given the food she craves for. This may include very nutritious food such

as blood, liver and kidneys. There is no custom of starving the pregnant women in the third trimester, like the Masai women sometimes do [104]. The delivery is usually assisted by the mother-in-law, and is associated with many religious concepts. If mucus obstructs the nose and mouth, the attendant may suck the face of the newborn after delivery. However, the colostrum is regarded as impure, and the infant is often given water the first few days until there is no meconium left [100]. Thereafter the mother usually lets the child exclusively breastfeed for 3-4 months. She may continue with some breastfeeding until the age two years. This is also reflected in obstetric histories of women in the area, where two years is the most common interval between children. After delivery, the mother is usually not allowed to move freely outdoors, and she is fed well. Still, a visit to a clinic for assessment and vaccination of a child is often accepted when the baby is a month [105].

A unique custom among the Iraqw, and the also the Datoga, is their seclusion practices, *meeta* and *metid.* It involves temporary cultural consequences of fertility related events like the death of the child, the death of a mother, and the pregnancy of unmarried girls [106]. Persons under *meeta* are excluded from normal social life and live separated from others. The household of a woman who loses a lactating child or has a still birth or an abortion, is in *meeta*. It usually lasts until the woman is pregnant again. Also, the house of a family where a pregnant or delivering or lactating woman dies, is considered to be in *meeta*. This practice may have an impact the completeness on follow-up in our study, and to some extent on the interviews with the deceased.

With the strong religious sentiment associated with pregnancy and childbirth, the adoption of antenatal services and modern obstetric care is not without reservations. Often we find traditional Datoga women rather sceptical, though not rejecting services altogether. The Iraqw have a tradition of employing foreign healers [98], which may be part of the reason why they accept more easily both antenatal clinics and modern obstetric care. Probably this has introduced some bias towards a higher proportion of Iraqw women in the antenatal cohort compared to the general population in the area. For utilization of hospital delivery services, the bias is probably stronger.

The staple food in the area is maize, usually eaten as porridge ("ugali") with green vegetables or with beans. Meat from chicken and goats is commonly used, while beef is used mostly at celebrations. Pigs exist in some "modern" households, but are regarded as unclean by the

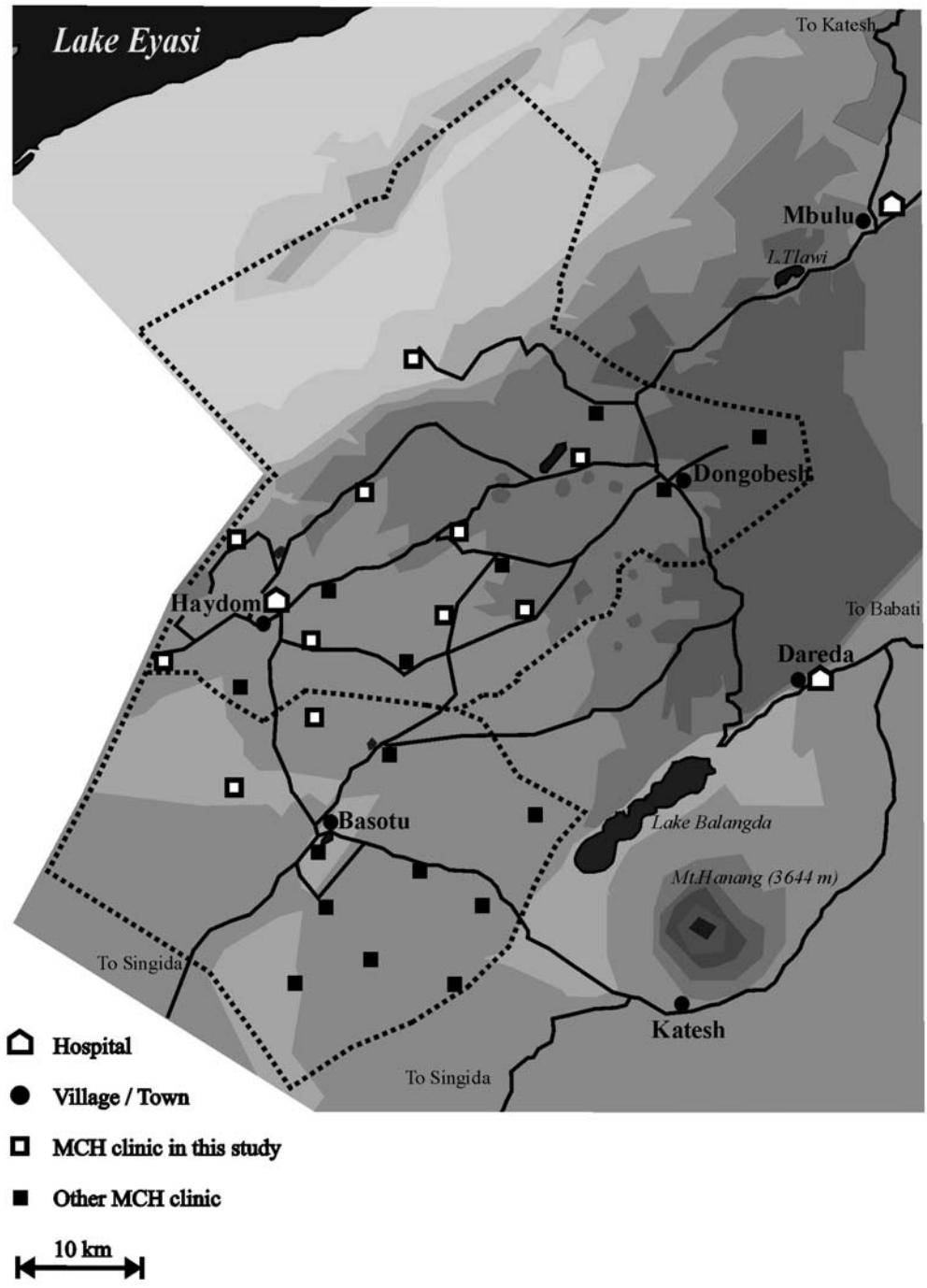
Datoga. All parts of the animals are used for food. Many households extract oil from sunflower. General famine is uncommon, but the area experienced a draught in 1999-2001, with below average rainfall and meagre crops. According to the previously mentioned household survey in the area, less than 4% had safe drinking water next to their homes. Only 28% had safe water within an hour's walking distance from home, the remaining households had longer distances. A household had on average 6.3 persons, and among the persons in these rural villages, 60% of the men and 40% of the women are literate.

3.2.3 The health services in the study area.

In the study area, there is one hospital, one health centre and 15 dispensaries, all presumably providing Basic Obstetric Care [107] (map of study area p.25). Only Haydom Lutheran Hospital (HLH) provides surgical services and Comprehensive Obstetric Care in the study area. Outside the study area there are hospitals in Mbulu (80 km from HLH) and in Dareda (110 km from HLH) offering Comprehensive Obstetric Care. In 1995 there was one health centre in Dongobesh and 14 dispensaries in the study area. Many of the dispensaries regularly assist deliveries, but they are often short of equipment. The study was conducted based at the HLH.

The District Medical Officer (DMO) in the district headquarters is the leader of health services in the district. All health facilities in the district report to him. The "Mother-and-child-health" (MCH) work is of the cornerstones in the primary health care, with an MCH co-ordinator stationed at the district hospital under the DMO, supervising and supplying vaccines and equipment. The MCH work is usually an integrated part of any health institution. MCH clinics offer antenatal examinations and counselling, child assessments, vaccinations, family planning and health education. Women or children with diseases or at risk of diseases are supposed to be referred to a higher level of care, i.e. a clinic or a hospital. Some institutions run outreach clinics in order to come closer to the users. An MCH team from the HLH visits the outreach clinics once monthly, usually taking place in a church or a government building.

Map of study area



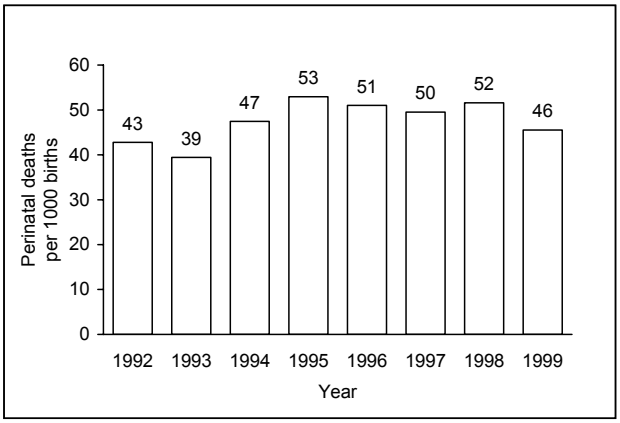
In 1995, 1% of the budget of Mbulu district was spent on health, and 37 % was spent on providing safe water sources (sponsored by donors) [108]. Sanitation is one of the tasks of the village health workers, and digging pit latrines was enforced by law. Pit latrines are becoming more and more commonplace, although not everybody has one. In the household survey we found that only 20-30% of the households had a latrine.

The largest health institution in the area is HLH, where the study was based. Annually, the HLH has approximately 60,000 outpatients and 10,000 admissions. The hospital runs an extensive MCH work, with one clinic at the hospital and 12 (1995) outreach clinics in remote areas to ease the access to maternity care for women living far away. An ambulance system exists at the hospital, with two vehicles collecting more than a thousand patients a year [109]. The payment for the transport is added to the total hospital bill, which prevents rejection of patients who have no cash immediately available. Maternity cases have priority, and represent a quarter of all the users. The users can request the ambulance directly at the HLH, or via the VHF-radio stations in the area.

3.2.4 Health and disease in the study area

The disease pattern in the study area is reflected in the statistics of the HLH from 1995 (Tables 2 and 3). Malaria is the most common ailment causing people to seek health services, and it is also the most common cause of death. Problems of the newborn also rank high on the list of cause of death.

Figure 3. Perinatal mortality rate at Haydom Lutheran Hospital 1992-99.



In 1995, there were 2190 deliveries at the hospital, 55 with twins and a triplet; 202 (9%) of the deliveries were done by a caesarean section. The maternal mortality ratio (MMR) in the area was recently estimated to be 300-400/100,000 [84-86]. The main cause of maternal mortality was cerebral malaria [86]. The perinatal mortality rate at the hospital is approximately 50/1000 births (Fig.3).

Table 2. The most common causes of death among hospital admissions at the Haydom Lutheran Hospital, 1995 [110].

Rank	Diagnosis	Hospital deaths
1	Malaria	357
2	TB	111
3	Prematurity	62
4	Pneumonia	49
5	Heart disease	36
6	Malignancy	25
7	Birth asphyxia	19
7	Diarrhoea	19
9	Meningitis	17
10	Malnutrition	14
11	HIV / AIDS	13

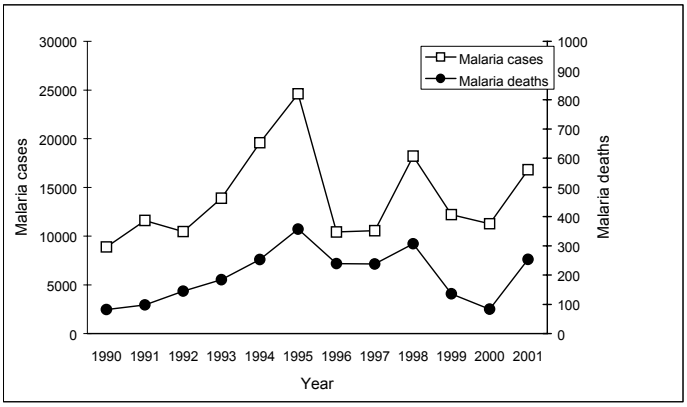
The deaths in the table represented 85% of the deaths at the hospital.

Table 3. The most common diseases diagnosed at the outpatient department of the Haydom Lutheran Hospital, 1995, Tanzania [110].

Rank	Disease	Outpatient cases
1	Malaria	19811
2	Pneumonia	3824
3	Amoebiasis	2433
4	Bronchitis	2124
5	Eye diseases	1808
6	Giardiasis	1807
7	Animal/insect bites	1747
7	Ear diseases	1497
9	Sore throat	1329
10	Gastro-enteritis	1269

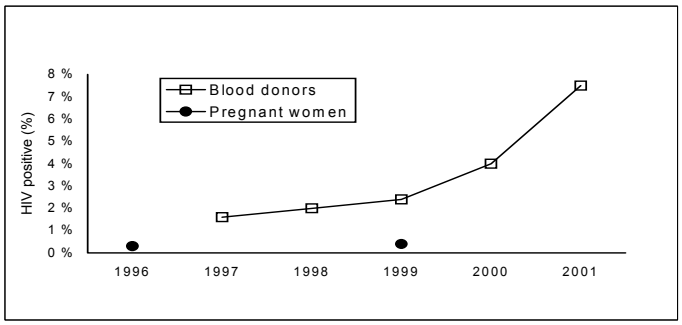
Evident from the hospital statistics, one of the major health problems is malaria, both with respect to morbidity and mortality. The area has a climate suitable for meso-endemic transmission. There are many malaria cases throughout the year, but the incidence increases during the rainy seasons, and all age groups are affected. According to hospital data of 1995, the Case Fatality Rate of *cerebral malaria* was approximately 30% for both children and adults. In addition to the annual increase in malaria incidence during the rainy season, epidemics are also seen when the annual incidence cycle is much larger than expected. The year of the field study was such an epidemic year (Fig.4).

Figure 4. Malaria cases and deaths due to malaria at Haydom Lutheran Hospital, 1990-2000.



The raging HIV epidemic in Tanzania with an estimated 1.5 million infected in 2002 [111], had not yet struck this area as hard as many other parts of Tanzania in 1995. The prevalence of HIV sero-positives among consecutive ANC attendees tested anonymously was 0.3% in 1996 and 0.4% in 1999 [66]. In 2001, there was a rise in the proportion of HIV sero-positives among blood donors (Fig.5).

Figure 5. Proportion of HIV-positive among blood donors at Haydom Lutheran Hospital**.**



Alcohol abuse and its adverse social consequences are becoming more common [97, 108, 112]. It may seriously have influenced the health seeking behaviour of patients and important decisions during pregnancy and childbirth.

A study of maternal morbidity and mortality in the area has recently been completed in a collaborating project [83-87]. It used mostly the same study subjects as this study.

The maternal mortality ratio (MMR) was estimated by using the "sisterhood" method [84]. The respondents' family histories were the basis for the calculations, namely, how many of the respondents' sisters died during pregnancy, delivery or shortly thereafter. It estimates the

MMR approximately 10 years prior to the survey. The MMR was estimated to be 362/100000 live births among women who attended the antenatal clinics in the area, and 444/100000 in the household study. This was lower than what has been found in other areas of Tanzania. Increasing distance of the ANC clinic to the hospital was associated with a higher MMR.

The maternal mortality ratio (MMR) was also estimated in other ways in the area [85]. In 1995 and 1996, 45 maternal deaths were found in the study area, using multiple sources. The MMR was estimated to be 388 (95% CI 250-560) per 100000 live births (using multiple sources), 322 (95% CI 160-580) per 100000 live births in the antenatal cohort, and 123 (95% CI 70-200) per 100000 live births using official statistics [85]. There was a severe underreporting from official statistics and health institutions.

The maternal deaths (n=45) that occurred in the study area during 1995-6 were traced, evaluated and analysed [86]. Indirect obstetric deaths (n=32, 71%) were more common than direct obstetric deaths (n=13, 29%) in this setting. The main cause of direct maternal deaths was hemorrhage, while among indirect causes, malaria predominated (n=20). The majority of the women died at a health facility (41 of 45), and 24 of the 45 women died postpartum. Only 11 of the pregnancies (24%) resulted in children who were alive at follow-up. Approximately 30% of the deaths were considered avoidable under the prevailing circumstances. The reasons were particularly delay in seeking help and failure of family to recognize the severity of the condition.

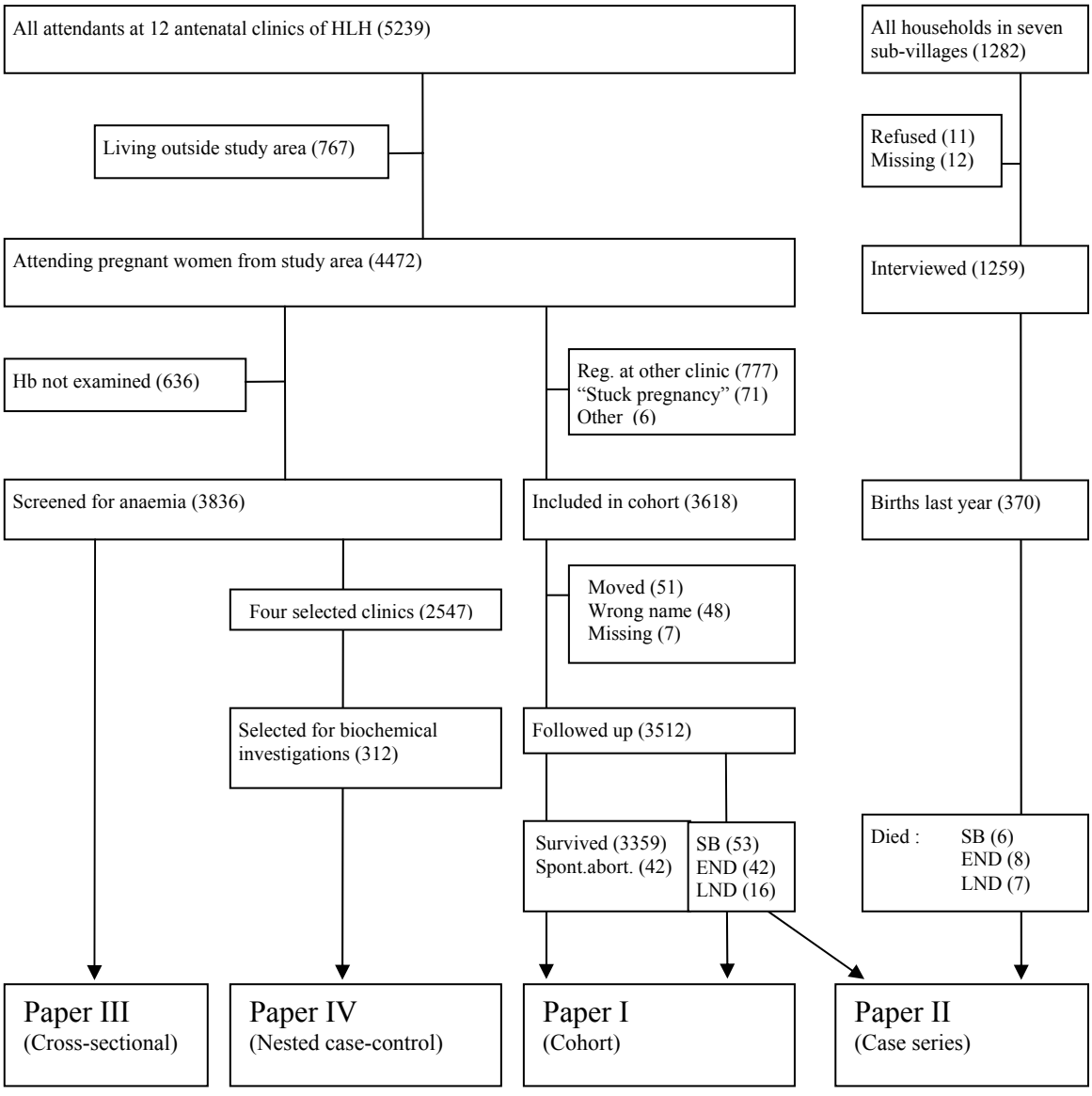
The cohort of pregnant women was also examined for urinary tract infections (UTI) [87]. Various examinations were done to detect different aspects of a UTI. The dipstick test for nitrite in urine for detecting bacterial activity was positive in 40%, whereas leukocyte esterase test showing leukocyte activity in urine was positive in 65%. A simple question about dysuria was positive in 32% of women. Bacterial culture using the Uricult® dipstick was positive in 16%. The prevalence of UTI was significantly higher in the rainy season for all the tests. The correspondence between the tests was poor.

4 Subjects and methods

4.1 SELECTION OF SUBJECTS

There were two sources of study subjects: one from a follow-up study at the MCH clinics run by HLH, and one from a simultaneous household survey. Our main source of subjects was the MCH clinics, where the research was done concurrently with the regular work. There were 12 antenatal clinics in the study area operated by the HLH, and the women attending these clinics

Figure 6. Outline of the study populations and selection procedures.
SB = stillborn; END = early neonatal death; LND = late neonatal deaths.



constituted our study population in this paper. We hired five field assistants to help collect the data at the MCH clinics, by recording results, examining the blood and urine, and conducting interviews. Usually two stayed at the MCH department of the hospital and three were going on outreach visits with the "mobile" MCH team. The field assistants were trained, and supervised throughout the data collection period.

The household survey covered 7 of the 183 sub-villages (vitongoji) in the study area, a total of 1282 households. The head of household was interviewed by a research assistant, and a woman of the house was interviewed by another research assistant. Only 12 households were missing and 11 refused to be interviewed.

Figure 6 shows the selection procedure of the study population. The antenatal clinic attending women were 5239, of whom 767 were living outside the study area. Of the remaining 4472 women, 3836 were examined for anaemia and constituted the study population for paper III. At four of the clinics, with 2547 attending women, we selected 312 women for a nested case-control study with serological investigations (Paper IV).

Among the 4472 attending women living in the study area, most of them were registered at the HLH clinics. However, some of the attendants (777) had registered at another clinic previously and were not included for follow-up. Some women later proved not to be pregnant and were excluded (71). A few (6) were excluded for other reasons. The remaining 3618 women, where we had full information and address, were followed up to assess the outcome of pregnancy (Paper I). We got information on the pregnancy from 3512 of them.

From the household study we identified 370 births that had occurred the previous year. Of them 6 were still births, 8 were early neonatal deaths, and 7 were late neonatal deaths. These were included in the case series together with cases from the cohort, as described in Paper II.

4.2 STUDY DESIGN

4.2.1 Paper I: Perinatal mortality.

Paper I is a follow up study of 3618 consecutive antenatal visitors who were registered at the antenatal clinic of HLH. The perinatal mortality rate and its determinants were assessed. Women attending the ANC clinics and who were living in Dongobesh and Basotu divisions

were included in a **cohort** and were followed up after delivery. The follow up of the attendees was done on the first visit after delivery, when the mother brought her new child for vaccination. The women who did not come back to the clinics, were traced back to their home village, and inquired about the condition of the mother and the child. Perinatal deaths include stillborn babies and early neonatal deaths. The perinatal mortality rate of a population is the number of deaths occurring during the perinatal period per 1000 *births*, and therefore including stillbirths in the denominator. This contrasts the definition of neonatal mortality rate, defined as the number of neonatal deaths per 1000 *live births*.

The outcome measures of this paper were the perinatal mortality rates and the risk of perinatal deaths. The determinants studied were parity, previous loss of child, previous miscarriage, birth weight, maternal urine nitrite, maternal anaemia, maternal malaria, maternal VDRL serology (Venereal Diseases Research Laboratory examination, unspecific syphilis test), and maternal arm circumference. The information on some determinants was incomplete in parts of the cohort.

4.2.2 Paper II: Avoidable stillbirths and neonatal deaths.

Paper II is a review of all the stillbirths and neonatal deaths that occurred in our cohort of 3618 pregnant women. In addition to the 53 still born and 42 early neonatal deaths described in paper I, we included the 16 late neonatal deaths from the same cohort. In order not to miss important causes of death among women who did not attend antenatal clinics, we also included women from the household survey who had lost a neonatal baby or had a still birth. There had been 370 births during the last 12 months prior to the household visits, 6 were still births, 8 died during early neonatal period and 6 died during late neonatal period.

The women in this **case series** who lost a neonatal baby or had a still birth, were identified, interviewed, and the cause of death was suggested. Three doctors independently evaluated the record of each case and reached a diagnosis, and where at least 2 doctors agreed, we kept the diagnosis. If all doctors had set a different diagnosis, we discussed the case and reached consensus. The cases were reviewed and commented upon by a paediatrician, whereupon we re-evaluated the diagnoses to reach consensus. For each case, we also assessed the avoidability of the death, whether patient-oriented or service provider-oriented. There are several ways of defining avoidable deaths. We defined a death as avoidable if there was a

preventable factor that likely contributed to death, *under the ruling circumstances*. We judged various degrees of likelihood for avoidability, and thus death would *probably* or *possibly* be averted if the factor was removed. We also assessed whether antenatal risk factors were present, and whether the mother of the deceased knew that she had a risk factor.

4.2.3 Paper III: Anaemia in pregnancy.

The women in the cohort were also examined for Hb and analysed **cross-sectionally** for (mostly) demographic determinants of anaemia (Paper III). We recorded 5239 attending women during the study period, and offered them Hb examination in addition to the ordinary antenatal routine investigation. Women who came from villages outside the study area were excluded from the analyses, and some women who later proved to be not pregnant, were also excluded. We included 3836 women to evaluate determinants of anaemia cross-sectionally.

The outcome measures of this study were Hb and the proportion of anaemic women (or "frequency of anaemia"), and we calculated the odds ratio ("risk") of anaemia. For analytical purposes, we defined three groups according to their Hb: one non-anaemic group with Hb ≥ 110 g/l as reference, one group with moderate anaemia with Hb 90-109 g/l, and one group with more pronounced anaemia with Hb < 90 g/l. The main determinants studied were maternal age, altitude of residence, ethnic group, religion, duration of pregnancy, parity, season, and malaria parasitaemia.

4.2.4 Paper IV: Determinants of anaemia in pregnancy.

We also wanted to examine the role of nutritional factors and infections as determinants of anaemia in pregnant women. Therefore we selected, according to their Hb results, some of the women in the cross sectional study into a **"nested" case-control** study. We selected 312 out of the 2547 screened attendants at 4 of the 12 antenatal clinics of the cohort in paper I. In order to have representative sample from different Hb levels, we chose a nested case-control study design (for details see Paper III). We analysed the groups Hb ≥ 110 (n=153), Hb 90-110 (n=89), Hb < 90 (n=70). We selected simultaneously from two clinics, and therefore the numbers were not equal in each stratum. The selected subjects were interviewed and gave venous blood for further examination.

Table 4. Prevalence of anaemia in cross sectional and "nested" case control selection.

	Hb < 90 g/l	Hb 90 – 109 g/l	Hb ≥ 110 g/l
Prevalence among all	5.1% (131/2547)	16.8% (428/2547)	79.6% (2027/2547)
Prevalence in sample	22.4% (70/312)	28.5% (89/312)	49% (153/312)

The outcome measures were defined as the risk of having anaemia with Hb below 90 g/l, and the risk of having anaemia with Hb 110-90 g/l. As determinants we examined both micronutrients and some markers of infections, and other characteristics: s-ferritin, s-Fe, s-TIBC, s-folate, s-cobalamin, s-vitamin A, s-C-reactive protein (CRP), s-lactate dehydrogenase (LD), s-haptoglobin, malaria blood slide, urine nitrite positive, and arm circumference.

4.2.5 Study power

The various parts of the study had various statistical powers to detect associations depending on the number of women included and the prevalence of the conditions being studied. Papers I, II, and III were based on the available data from a cohort of all ANC clinic attending women for about a year. The size of the cohort was determined by the attendance of pregnant women and the available time frame for data collection.

Table 5. Study power (1-β) to detect associations between determinants and anaemia (Hb < 90 g/l), according to the odds ratio of the determinants.
There were 70 cases with Hb < 90 g/l, and 153 controls with Hb ≥ 110 g/l.

OR	Study power (%)				
	Prevalence of exposure among controls				
	5 %	10 %	20 %	30 %	50 %
1.5	11,9	18,3	27,7	33,0	34,7
2	30,3	48,9	68,3	75,4	74,6
3	71,7	91,2	98,0	98,8	97,7
5	98,5	99,9	99.9	99.9	99.9

Paper IV was based on a case-control study "nested" within the cohort. Altogether 312 women with various levels of Hb had been included to facilitate comparisons of both pronounced (Hb < 90 g/l) and mild (Hb 90-109 g/l) anaemia with normal controls (Hb ≥ 110 g/l). The power (1-β) in paper IV to detect associations between *pronounced anaemia* and the determinants are given in the Table 5. Among controls, the prevalence of most of the

exposures of determinants was 15-50%. Evident from Table 5, an odds ratio (OR) of 1.5 was difficult to detect even for prevalent exposures. An OR of 3 or more was, however, likely to be detected. A determinant with an OR 2 would likely be detected for risk factors with high prevalence among controls.

4.3 LABORATORY METHODS

For examination of hemoglobin concentration, we used two HemoCue® devices measuring capillary blood, one for the MCH clinic at the hospital, the other for the outreach ("mobile") clinics. Thick blood slides were prepared according to the routines at HLH, using capillary blood and Field staining. The number of plasmodia per 100 white blood cells was recorded. In negative slides, at least 20 fields were examined before stating negative, which is lower than what is recommended [113]. This could increase the number of false negative slides, but not influence the positives. It could partly explain why malaria slide is not very closely associated with anaemia, but blood-slide negative malaria is a very well-known clinical problem in the area. A mid-stream urine sample was obtained from the women, and a Uricult® dipslide culture of the urine was done, incubated for 18-24 hours at 37C° and then recorded. A Nephur6® dipstick test was also done, giving instant result of nitrite, leukocyte esterase, glucose, albumin, and blood in the urine. Reading of results was done after a minute, according to manufacturer's instructions.

Women selected for a study on anaemia, were venipunctured with a Vacutainer® system. The blood was left for 30 minutes to clot, centrifuged and the serum was then pipetted into sterile tubes. The sera were frozen at -21 C°. The sera melted once due to electricity failure. The frozen sera were brought to Laboratory for Clinical Biochemistry at Haukeland University Hospital in Bergen by air. Then the sera were analysed for vitamin A, iron status, folate, cobalamin, CRP, LD, haptoglobin, creatinin, and vitamin E. Some of the sera had insufficient quality for CRP and haptoglobin analyses. In our analyses, we used the definitions of abnormal values given in Table 6.

Table 6. Abnormal values for laboratory methods used.
Most of them depicted from manual of the laboratory [114].

Analysis	Abnormal values	Method/Equipment
B-hemoglobin (Hb)		HemoCue B-Hemoglobin, HemoCue
	< 110 g/l*	*WHO definition for anaemia in pregnancy.
	< 90 g/l**	** Used in analyses in Paper III and IV
	< 70 g/l***	***WHO definition of severe anaemia
S-cobalamin	< 150 pmol/l	MSA, Technicon Immuno-1, Bayer Corp.
S-C-reactive protein (CRP)	< 10 mg/l	Immunoturbidometric, Orion Diagnostics.
S-ferritin	< 15µg/l	MSA, Technicon Immuno-1, Bayer Corp.
	< 50 µg/l*	* if CRP > 10 mg/l, [115]
	> 75 µg/l**	** 97.5 percentile of non-anaemic women in the study
S-folate	< 4.5 nmol/l	MSA, Technicon Immuno-1, Bayer Corp.
S-haptoglobin	< 0.4 g/l	Behring Nephelometer Analyser II, Dade Behring.
S-iron	< 11 µmol/l	Spectrophotometer, Technicon Chem-1, Bayer Corp.
S-lactate dehydrogenase (LD)	> 450 U/l	Spectrophotometer, Technicon Chem-1, Bayer Corp.
S-TIBC	> 72 µmol/l	Spectrophotometer, Technicon Chem-1, Bayer Corp.
S-transferrin saturation	< 16%	Calculated by formula: Tfsat= (100 x Fe/TIBC) %.
S-vitamin A	< 0.7 mmol/l	High performance liquid chromatography.
Urine leukocyte esterase	+, ++, +++	Nephur 6, Boehringer-Mannheim.
Urine nitrite	(+) and +	Nephur 6, Boehringer-Mannheim.

4.4 DATA QUALITY ASSURANCE

The two HemoCue® hemoglobinometers were tested against their respective standard cuvette daily and cleaned regularly. They were calibrated to the correct value whenever the standards showed wrong value.

On days with only the hospital clinic open and no outreach clinics, we examined the same blood sample in both instruments for agreement between them. One instrument showed a slightly higher Hb than the other, on average 5 g/l. This was within the given accuracy limits of the instruments. Adjusting the results of the instrument showing the lowest values, would have given a total mean Hb of 124 g/l instead of 121 g/l.

In order to assess reproducibility of interview-derived variables, some of the interviews were repeated by a different interviewer after a week or more. The variables obtained were compared by kappa analysis, and showed good correspondence. Some selected variables are

shown in Table 7. As expected, the woman's statement of her own private status was more consistent than her account of her husband's status.

Table 7. Selected kappa values for validation of the antenatal questionnaire, assessed on interviews of 58 of the pregnant women.

Variable	Kappa
Woman's ethnic group	0.8
Woman's religion	0.9
Woman's age	0.88
Woman's literacy	0.9
Woman's education	0.95
Husband's education	0.84
Possession of cows	0.75

The mean recall period for verbal autopsies was 6 months, with a range from 3 months to 3 years. We deliberately waited some months, in order to avoid the period of deepest grief. For deaths, recall has been shown to be accurate even after long time [116, 117].

A field assistant reviewed all the completed interviews, and then one of the principal investigators reviewed it. The data were entered into an EpiInfo 6.04 database. A second data entry was done for validation of the data, and where errors were detected, they were corrected. The error rate was below 1 %, except for spelling errors for alphanumeric variables. The data were converted from EpiInfo to SPSS, and "cleaned" by reviewing frequency tables and checking outliers.

4.5 ANALYSIS

The data were analysed using the SPSS versions 7 and 9.

In the cohort study on the outcome of pregnancy, we also used multiple logistic regression analysis to study risk factors for perinatal death, adjusting for parity and prior loss of child, which were potential confounders. In the case series with stillbirths and neonatal deaths, we used chi-square tests and chi-square test for trend to calculate the p-value of the results. The significance level was 5 % and all tests were two-tailed.

In the cross sectional study on anaemia, we used multiple linear regression analysis to study the determinants of Hb, and used the regression coefficients (with 95% CI) as a measure of association between Hb and the determinants. In the nested case control study on anaemia, we

used multiple logistic regression analysis to study the determinants (risk factors) of anaemia. The resulting odds ratio was used as an approximation for relative risk. Adjustments were done according to considerations of potential confounders. Generally, we found a need for adjustment for gestational age, altitude, and season.

Because of the high altitude, the distribution of Hb was slightly shifted to the right in our study. In order to compare with studies done at other altitudes, we calculated the corresponding hypothetical Hb at sea level, and applied the anaemia cut-off on these standardised Hb values. The correction factors given by Centers for Disease Control and Prevention (CDC) [118] was given by broad altitude bands, and no formula for the correction factor was given, though it fits well with a function involving the squared altitude. Based on Hb among children at various altitudes in the Andes, Dirren calculated the association between Hb and altitude by a "Goodness of fit" analysis [119]:

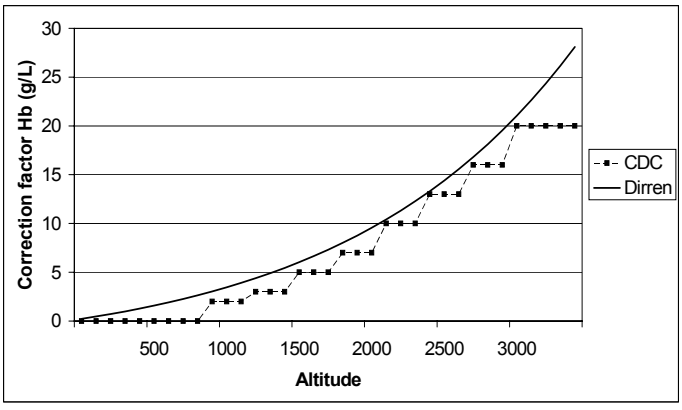
$$Hb = 3.44 \times e^{(0.00063 \times \text{altitude})} + 116.9.$$

Based on this equation (with Hb given in g/l), we calculated the following correction factor, to be subtracted from the measured Hb:

$$\text{Hb correction factor for altitude} = 3.44 \times (e^{(0.00063 \times \text{altitude})} - 1).$$

This closely resembles a simple square function (Fig.7).

Figure 7. Altitude correction factor for Hb (g/l) to be added to the measured Hb.



4.6 ETHICAL CONSIDERATIONS

The research protocol was approved by the Regional Committee for Medical Research Ethics in Bergen, Norway, and by the Commission for Science and Technology in Tanzania

(COSTECH). The permission letter from COSTECH was brought to the Regional Development Director, who issued letters of recommendation to bring forward to the two districts involved. At district level, we introduced the letters to the District commissioners of Hanang and Mbulu districts, who issued new recommendations to bring to the division, ward and village leaders in the study area. With these letters, we introduced ourselves and our objectives and plans to the village leaders, and also requested vital statistics reporting from them. They arranged plenary meetings with the people involved in the household surveys, where we introduced ourselves and presented the objectives and plans for the research. We also had meetings with the administrative staff at the Haydom Lutheran Hospital, and in particular the staff at the MCH clinics.

The participants were also asked individually for oral consent, and those who were found to have anaemia, genito-urinary tract infection, or malaria were offered free treatment. The few women who refused to participate were given the same antenatal service as those who participated. No remuneration was given to the participants.

5 Synopsis of papers

5.1 Paper I: Perinatal mortality in rural Tanzania.

The objective of this paper was to study the perinatal mortality rate and risk factors related to nutrition and infections in a rural population in northern Tanzania. We registered 3618 women attending antenatal clinics and followed them up after delivery. We recorded name, address, date, age, ethnic and religious affiliation, and obstetric history. Further, results of urine nitrite test, Hb concentration, and malaria blood slide result were registered. In a sub sample (also used in Paper IV) we recorded VDRL test and arm circumference. Women who had experienced stillbirths and neonatal deaths were identified and interviewed. No information on the outcome of pregnancy was obtained on seven women and on 99 we had incomplete information.

The perinatal mortality rate was 27/1000 births (95% CI 22/1000 to 33/1000], 44% were early neonatal deaths and 56% were stillborn. There was an increased risk of perinatal death among babies with low birth weight (OR 5.8 for babies 2000-2499 g), among babies of women with a small arm circumference (OR 5.7), among babies of women with positive VDRL serology (OR 5.1), among babies of mothers who had previously lost a baby (OR 1.9), and among babies nulliparous women (OR 1.7).

The perinatal mortality rate was lower than in other studies from Tanzania and East Africa. This was possibly due to a good, accessible and widely used obstetric and perinatal care, and an existing ambulance service which could be requested via a radio-communication system, minimising the delay. Perinatal health improvement may be achieved at antenatal clinics through detection of maternal infections and maternal poor nutrition. Improving survival of babies with low birth weight can probably only be achieved at a hospital with good neonatal care.

5.2 Paper II: Avoidable stillbirths and neonatal deaths in rural Tanzania.

The objective of this paper was to determine the underlying causes of stillbirths and neonatal deaths in the community, and to evaluate whether the deaths were avoidable under the prevailing circumstances. We audited 139 deaths identified through two sources. We identified 119 stillbirths and neonatal deaths in a prospective cohort of antenatal attendees

(described in Paper I) and we identified 21 additional stillbirths and neonatal deaths retrospectively in a household survey in 7 rural communities. One case was reported from both sources. Verbal autopsy was done to reach a diagnosis, in many cases supplemented with information from antenatal records and hospital records. The avoidability of death was assessed for each case, reviewed in light of the existing circumstances. An account of risk factors detectable at antenatal clinic was done by reviewing the ANC cards and ANC registers, and was compared with the woman's recall of the risk assessment and recall of being referred. Three of the cases were identified but had moved so no verbal autopsy could be done. We analysed 136 cases.

There were 60 stillbirths, 29 early neonatal deaths and 27 late neonatal deaths. Infection-related deaths were most common (n=53, 38%), followed by asphyxia-related deaths (n=32, 23%) and immaturity-related deaths (n=20, 14%). Malaria was the most common infectious agent observed (21 children and 20 mothers). Half of the babies (n=65) were born at home, and slightly fewer died at home (n=55). 21 deaths (15%) were probably avoidable, and 13 (10%) were possibly avoidable. A patient-oriented avoidable factor was identified in 17 cases (51%) and a provider oriented avoidable factor was identified in 22 cases (65%). A maternal risk factor identified at ANC before delivery was present in 26 of the 34 cases of avoidable death, but only two of the women were aware of it, and only one recalled being referred to a hospital for the risk factor.

In this study, the causes of death were similar to other studies in Africa. The relatively low proportion of avoidable stillbirths and neonatal deaths may be partly due to an accessible emergency obstetric care in the area, also reflected in the relatively low perinatal mortality rate. Future efforts should emphasise improving the communication at the antenatal clinics, preparing the women and their families for the delivery, and preparing them for sudden complications.

5.3 Paper III: Anaemia in pregnancy in the highlands of Tanzania.

This study describes the prevalence and determinants of anaemia among rural pregnant women living at 1300-2200 meters above sea level in Northern Tanzania. Between January 1995 and March 1996, 3836 pregnant women from two divisions of Mbulu and Hanang districts attending antenatal clinic were assessed cross-sectionally. Blood samples were examined for hemoglobin concentration (Hb) and thick blood slide (BS) for malaria.

Information on date of examination, village, age, ethnic and religious affiliation, gestational age, and parity was recorded. Altitude was derived from official maps. Main outcome measures were mean Hb and risk of anaemia, defined as Hb less than 9.0 g/dl. The associations between Hb and the determinants were examined in multiple linear regression analysis, and the risk of anaemia (adjusted odds ratio, AOR) was estimated by multiple logistic regression analysis. Adjustments were made for gestational age, season, maternal age and parity.

Mean Hb was 12.1 g/dl, ranging from 4.5 to 18.1 g/dl. Twenty-three per cent had Hb of less than 11 g/dl, 4.6% less than 9 g/dl and 0.5% less than 7 g/dl; standardised to sea level 36.1%, 8.8%, and 1.1%, respectively. The mean Hb increased by 0.3 g/dl per 200 m increased altitude, and the risk of anaemia decreased with a factor of 0.6 per 200 m increased altitude. We found higher risk of anaemia (Hb < 90 g/l) at higher maternal age (1.2 times increased risk per 5 years). Furthermore, the Datoga had twice the risk of anaemia compared with the Iraqw. When going through a pregnancy, the risk of anaemia doubled from 3-4 months of gestation to 7-8 months. The risk of anaemia increased six-fold in the rainy season of 1995, and the risk was almost double among those with malaria parasitaemia.

The findings indicate that anaemia in pregnancy was common in this area of high altitude in rural Tanzania, but less prevalent than indicated by studies from most other parts of the country. The study confirms that preventing anaemia is a challenge in preventive antenatal care in the highlands of Tanzania.

5.4 Paper IV: Anaemia in pregnancy in rural Tanzania: Associations with micronutrients status and infections.

In this paper, we studied the association between anaemia in pregnancy and characteristics related to nutrition and infections. We selected four of the 12 clinics in Paper III (and Paper I) for this study, including the largest at Haydom Lutheran Hospital. We screened 2547 women for hemoglobin (Hb) and malaria plasmodia in capillary blood, and for infections in urine. According to their Hb, they were assigned to one of five groups and selected accordingly, Hb < 70 g/l (n=10), Hb 70-89 g/l (n=61), Hb 90-109 g/l (n=86), Hb 110-149 g/l (n=105), and Hb ≥ 150 g/l (n=50). We aimed at a fairly balanced number in each group, except in the lowest and the highest group where we intended to include all. The difference in

numbers arose because of simultaneous data collection at some clinics. The 312 selected subjects had venous blood drawn and were interviewed, and their arm circumference was measured. The sera were analysed for ferritin, iron, total iron binding capacity (TIBC), cobalamin, folate, vitamin A, C-reactive protein (CRP), and lactate dehydrogenase (LD). Transferrin saturation (Tfsat) was calculated. Urine was examined by dipsticks for nitrite. The associations between anaemia and the determinants were estimated by multiple logistic regression analysis, using adjusted odds ratio as an approximation for risk.

Anaemia (Hb < 90 g/l) was associated with iron deficiency (low s-ferritin: AOR 3.4). The association with vitamin deficiencies were significant in unadjusted analysis (low s-folate: OR 3.1, low s-vitamin A: OR 2.6). Anaemia was also associated with markers of infections (elevated s-CRP: AOR 3.5, urine nitrite positive: AOR 2.4) and hemolysis (elevated s-LD: AOR 10.1). A malaria positive blood slide was associated with anaemia in unadjusted analysis (OR 2.7). An arm circumference less than 25 cm was associated with anaemia (AOR 4.0). The associations with less severe anaemia (Hb 90-109 g/l) were similar but weaker.

The management of anaemia at antenatal clinics should aim at identifying potential infections, particularly malaria, and treating accordingly. Anaemic women without infections should not only be considered for iron deficiency, but folic acid and vitamin A as well.

6 Discussion

6.1 METHODOLOGICAL CONSIDERATIONS

6.1.1 Selection of subjects and potential selection bias

The subjects in our cohort were enrolled through the existing ANC clinics run by HLH. The number of subjects registered in the cohort was 3618 during the 410 days of enrolment. The expected number of pregnancies in the study area during 410 days was 7700 (population 143,000 and local crude birth rate (CBR) 47.7/1000, Paper I), so the study covered approximately 47% of the expected pregnancies in the study area during the data collection. In the household study we found that 90 % of pregnant women had been attending an ANC clinic at least once (Paper I).

The study included pregnant women attending 12 ANC clinics run by HLH. In addition, there were 16 other clinics in the area. Since the clinics in the study were run by HLH and therefore belonged to the Lutheran Diocese, one could argue there was a potential selection of women with this denomination. However, women who were not "Protestants" (Catholics or traditional beliefs) were as numerous as the "Protestants" (see Paper I, Table). Usually, the pregnant women would attend the nearest clinic. The belief of the study subject was not a risk factor for perinatal death. We think the selection of study subjects should be fairly representative for the population in the villages covered by the 12 clinics.

No women refused to participate in the cohort study, but some women may have missed registration by avoiding the queue for blood- and urine-test where the recording of the participants took place. A few women had to go home immediately, and could not take time for an interview for the anaemia study.

Some of the study participants (21 of 139) for the study on avoidable still births and neonatal deaths were selected from the household study (Paper II). The household survey covered almost all the households (over 98%) in 7 out of the 42 sub-villages in the area and should give a representative figure. The selection of the sub-villages was done after discussions with the ward leaders, partly based on expected ethnic distribution, partly based on practical and logistical reasons. Potential pregnant women not attending an ANC clinic should therefore be

picked up by this procedure. The cases were however not different from the cases from the cohort.

We observed a generally very positive attitude to the ANC, and we observed an increase in number of attending women during our fieldwork. A woman would often avoid the clinics during the first months of her pregnancy. During the household study, we found some women who had not attended ANC at all during their pregnancy (approximately 10%). Often these were multiparous women who were too busy at home to go to the clinic, and thus did not constitute a large group of "high-risk" women.

Because of the special seclusion practices among the Iraqw and the Datoga which has quite a stigma attached to it, there were probably fewer unmarried women in our cohort than in the general population. Also, ANC being regarded as a modern health care service, it is easily accepted by women with education. In our sample the young and the uneducated may therefore be somewhat underrepresented compared to the population at large. This may theoretically give a lower estimate of the PMR.

6.1.2 Considerations on the outcome measures and determinants

6.1.2.1 Perinatal mortality

The pregnant women in the cohort were followed up until at least one month after delivery. No telephone lines existed for contacting the participants, and most people had no mailing address. Therefore, if a woman did not return to the clinic with her baby, we traced her physically to her home village. The women had registered at the clinic with name, father's name, husband's name, the name of the ten-cell leader, and village. The loss of follow-up may be related to the pregnancy outcome. In seven cases (0.2%) the information on the outcome was completely missing. If all of these pregnancies ended with a death, it would only slightly increase the PMR from 27 to 29/1000. In 106 cases (2.9%), the information on outcome was incomplete. They had either moved out of the study area (51), or their names were unknown by the neighbours and village leaders indicated on their registration (48). It was quite common for people to move, although the majority of the population was fairly stable. One of the reasons for moving might be an ominous incidence such as a death. If the family had moved, we always asked the village leaders and the neighbours for news about the mother and

the baby. Although they could not always confirm survival, they would usually know about a death, especially if this was the reason for moving.

Follow-up in a developing country may pose serious challenges to achieve acceptable drop-out rates. A follow up study of outcome of pregnancy in Mozambique resulted in a drop-out rate of 9% of 908 women[120], and a study in Malawi had a drop out rate of 2.2 % of 795 women [121]. Our drop-out (2.9%) rate was comparable with the latter.

We discussed the unknown cases with village leaders and villagers, and reached the conclusion that they must have registered with a pseudonym and wrong address. Divorce and remarriage was not rare in this area [122], and it was not uncommon that a woman would run away from her husband, e.g. because of domestic violence. She would then adopt a new identity and live on with another family, and she would ensure that her former husband could not trace her. When she got pregnant again, she would usually not inform the staff at the MCH clinics about this, since revealing her real name posed a risk of being recognised by people who knew her former husband. We actually managed to identify one woman who had used a pseudonym and was hiding from her violent previous husband, but generally the verification of the outcome of pregnancy was impossible in these cases. The PMR among these women would presumably be (similar or) somewhat higher than the rest of the cohort because of potentially less favourable health seeking behaviour. If the PMR was doubled (PMR 60/1000) among the 48 cases with pseudonyms, we might have missed up to three deaths. This would not seriously influence the mortality estimates of the total population.

There may have been cultural reasons for avoiding exposure for families who lost a baby. As mentioned earlier, the deaths we were trying to trace were regarded as potentially harmful, particularly for vulnerable people like newborns and mothers. Usually the women were happy to share their experience with the interviewer, a doctor whom they had seen during ANC visits.

Sometimes the follow-up was more cumbersome than we had expected, because the women often used their Christian or Muslim names when registering at the clinics, whereas they were known by their traditional names at home. Furthermore, a woman was often known by the name of her husband, or by the name of her firstborn child, and not by her real name. Another complication occurred when the father of an attending woman converted to Christianity. The

woman would then register with the father's new name as her family name, and the new Christian name would often be unknown in the village. However, we usually found out by contacting several villagers in the area where we expected to find her.

We do not know whether the women with potentially higher risk (unmarried women, women with a difficult situation at home) were refused attending ANC by their fathers or husbands. As mentioned earlier, the pregnant unmarried women were in *meeta* and they were therefore regarded as dangerous for other pregnant women. They would avoid crowds and pregnant women, like antenatal clinics. This could introduce a selection bias where unmarried young women and women with a difficult situation at home were underrepresented in the cohort. These women have a potentially slightly higher risk than most women, and therefore our estimate of PMR may be slightly lower than in the general population in the area.

Stillbirths before seven months of gestation were not defined as perinatal deaths. The mother usually knew the approximate gestational age well, even though she often could not indicate the exact dates for the last menstrual period. This inaccurate estimation of gestation poses a risk of misclassification of six-months-stillborn and seven-months-stillborn. We think these will cancel each other out, and the importance is probably minor as they will be of fairly similar age.

Many women (43%) paid their first visit to the antenatal clinic in the last trimester, but less than 10% waited till the last month of pregnancy. In the population of pregnant women, there may have been some women who had a stillbirth before ever attending the clinic. Since the still birth may have precluded the woman from selection into the study by waiting to attend the ANC till late in the pregnancy, it entails a potential bias of underestimating the PMR in the study area. Theoretically, if all women were enrolled at conception, we would find a slightly higher stillbirth rate than we actually found in our cohort. However, in our study there was no difference in the stillbirth rate among women who registered their pregnancy at the ANC early (before 7 months, 15/1000) and later (≥7 months, 15/1000).

6.1.2.2 Causes of stillbirths and neonatal deaths

We used the "Verbal Autopsy" as a tool for assigning a diagnosis as the cause of death. The Standard Verbal Autopsy questionnaire published by WHO [123] was not available at the time of the study, but we used a questionnaire modified after Smith & Morrow [124]. The specificity

and sensitivity of the tool varies with the diagnosis, but generally the results are subject to a relatively high degree of misclassification errors. Diagnoses like malaria and pneumonia have achieved a specificity of 90%, but with sensitivities below 50% [125-127]. The accuracy of the estimates are usually more dependent on a high specificity than a high sensitivity, and also depends on the prevalence of the diagnosis in the material [128]. We improved the specificity of the verbal autopsy by using additional information from hospital records. In addition, the interview itself was conducted by medical doctors, increasing the precision of the tentative diagnosis [129]. Surprisingly, misclassification in itself does not necessarily decrease the accuracy of the estimate, since over and under-estimation may cancel each other out [128].

Instead of using the specific diagnoses reached by the audit of the verbal autopsies, we classified the diagnoses into functional groups [130], which was partly based on the Wigglesworth classification [131]. This grouping improves the performance of the verbal autopsy tool.

The recall of parents is unsatisfactory after minor illnesses, but it is fairly good after serious events such as a death, even after a long time [116, 127, 132, 133]. In our study there was good correspondence between information from parents and from hospital, although only a limited number had information from both sources.

6.1.2.3 Avoidability of stillbirths and neonatal deaths

The deaths identified through this cohort were studied in detail as a case series ("perinatal audit") to identify the underlying cause of death (diagnosis) and avoidability of the death (Paper II). Some of the information used in this study was based on examinations done during pregnancy. Other information was obtained through an interview with the bereaved family, and gave us information on the symptoms and the circumstances of death.

The case series in paper II was taken from the cohort of attending women as well as from women in the household study. The mortality rates as well as the distribution of causes of death were similar in the two case series. Therefore, we find it unlikely that severe selection bias influences the results based on the cohort.

In paper II we assessed the avoidability of stillbirths and neonatal deaths in an audit. The definition of avoidability that we used was not whether the diagnosis or condition was

theoretically treatable or not, a definition that some authors use [134-136]. Others evaluate each case individually with assessment of errors or omissions in the management of the condition[137, 138]. We assessed whether the death could or should have been avoided *under the prevailing circumstances*, thereby indicating possible human errors or omissions, which has been the focus of most of the African studies on avoidable deaths[139-146]. Therefore, what was unavoidable in this setting could have been avoidable in other settings e.g. treatable under better conditions. This may limit the generalizability of the results to rural areas in developing countries.

During the verbal autopsy interview we also tried to assess the woman's knowledge about her risk factors during the pregnancy that ended in a stillbirth or neonatal death. We asked her: "Did you have any risk factors (Swahili: *vidokezo vya hatari,* literally 'hints of danger') on the antenatal clinic card?" Some women responded that they did not know or could not recall. If she answered "no", she would have either no risk factor or would not have been told about any risk factor, or would have misunderstood the message from the midwives. Whichever option, she would have no knowledge of her risk assessment. Her response would therefore indicate her *knowledge* of the risk assessment, not the absence or presence of risk factors. As described in Paper II, the knowledge of risk assessment was very low among the mothers of the deceased infants, which should encourage midwives to improve their communication. This unsatisfactory result was not surprising. On a busy outreach clinic day, two midwives would serve more than 100 pregnant women. Needless to say, the time spent on each pregnant woman was limited. Furthermore, the women attending the most remote clinics were often not fluent in Swahili, and if the midwife was from another tribe, she would need one of the other midwives or staff to translate for her to obtain any degree of communication. The staff at the clinics were painfully aware of the problem and have later tried to organise themselves in a more rational way.

Through the verbal autopsy we also tried to evaluate whether the deceased woman had been referred to a health facility – higher level of care - during the pregnancy. The pregnant woman would likely not miss this message, though the problem of recall still remains. Our study indicated that the referral system did not function according to the intentions.

As a result, almost no *elective* caesarean sections were done at Haydom Lutheran Hospital. This is a general problem in Tanzania[147] and other developing countries [148], and is a

contributing factor to the failure of the *risk approach* (section 1.2). We think the weakness is probably partly inherent in the system, partly in the mentality of the users of the system. There is a general reluctance to prepare for disaster or complications, in fear of provoking it to happen. A fatalistic attitude, acknowledging God's will in what happen, may make it easier to deal with pain and sorrow after a death, but may undermine the motivation to prepare for the unexpected.

6.1.2.4 Hemoglobin and anaemia in pregnancy

The study design of the Paper III dealing with anaemia was cross-sectional. The study population consisted of the pregnant women in the area. For more than a year (410 days) we selected all the women attending the 12 antenatal clinics run by HLH in the study area for a cross-sectional survey. Some women who were registered had only the urine examination done, and avoided the Hb examination (Fig.6, 14%). Our impression was that some of them were afraid of the finger puncture, and maybe some avoided queuing to save time.

The **definition** of anaemia has been much debated. WHO criteria for pregnant women define anaemia as Hb below 110 g/l, and severe anaemia as Hb under 70 g/l [49]. The Hb in normal non-deficient pregnant women has a basically normal distribution with mean 112-113 g/l (in the study area). The Hb distribution of anaemic women is wider and with a longer left tail, and it overlaps with the Hb of non-deficient women. Using a fixed cut-off to define anaemia will invariably result in some healthy women with a low normal Hb being defined as anaemic, and some women who usually have a high Hb but now have a reduced Hb (but still above the limit), will be defined as non-anaemic. Hb of 110 g/l may be normal in one woman and too low in another. However, Hb below 90 g/l is always abnormal. Comparing Hb < 90 g/l with Hb ≥ 110 g/l minimised the overlap of the anaemic and the non-anaemic. In our sample, the women with Hb < 70 g/l were too few for sensible separate analysis, and instead we created a group of women with Hb below 90 g/l (by joining the two groups with Hb < 70g/l and Hb 70-89g/l).

In a normal pregnancy, the physiological expansion of the plasma volume leads to a decreasing Hb in the first and second trimesters. The Hb increases a little in the last trimester, giving the characteristic U-shaped curve throughout pregnancy [51]. Several authors and The National Academy of Sciences (USA) have advocated defining anaemia according to the **gestational** age, e.g. Hb < 110 g/l in first and last trimester and Hb < 105 g/l during second

trimester [149]. Our participants were measured at different stages of pregnancy, and even though we could not follow each participant regularly *throughout the pregnancy* with Hb, the mean Hb of different women at the various stages reflected the physiologic hemodilution (Fig.2, Paper III). Applying the arguments above on our study, the women in the second trimester with Hb of 105-110g/l were misclassified as (moderately) anaemic. We have tried to avoid the ambiguity by referring the Hb value and not "anaemia". The association between Hb and gestational age represented a strong potential confounder for other associations, and we therefore adjusted for gestational age (month) in all the analyses.

The **instruments** used for Hb measurements were two portable HemoCue® B-Hemoglobin photometers with rechargeable batteries. They were easy to operate and have been recommended as research tools [150], but they are somewhat expensive for routine screening procedures in developing countries. The manufacturer indicates an accuracy of 1.5% (corresponding to 2.2 g/l for a "normal" Hb) [151]. The instrument correlates well with other instruments for Hb measurement, like the Coulter [150], but it may read consistently lower, in the order of 3% [152]. If our instruments read 3% lower than the "true" Hb, the overall actual mean Hb would have been 125 g/l instead of our result 121 g/l, and the prevalence of anaemia with Hb below 110 g/l would be 30.0 % instead of our estimation 36.1 % (Paper III). The test would have better specificity for anaemia, but less sensitivity. Such a systematic error could influence the associations we found and the statistical power of the associations.

Venipuncture of all the women in the cohort was not feasible. Therefore, we used **capillary** blood to measure the Hb for screening purposes. Capillary blood shows more variation than venous blood [153, 154]. Using the first drop of blood after the puncture does not give acceptable precision[154], but drying the first drop and using the next improves the precision. In order to standardise the conditions, we trained the field assistants to a correct sampling technique and supervised throughout the project.

The participants in the study were living at various **altitudes**, ranging from 1300 to 2200 meters above sea level. We applied Hb standardised to sea-level on the WHO cut-off points of anaemia in order to compare the prevalence of anaemia with other studies. Even though the mean Hb was only slightly reduced by this standardization to seas level (from 121 to 114 g/l), the proportion of women with Hb < 110 g/l increased from 23% to 36% (Paper III). In all the

other analyses of determinants of Hb and anaemia (Papers I-III), we used the measured (not the "sea-level standardised") Hb, but adjusted for altitude in the regression models because it represented a potential confounder in relation to other associations.

Dehydration may influence the Hb by hemoconcentration, resulting in a spuriously high Hb. The hydration status of the women attending the antenatal clinics was probably not uniform since there was a marked difference in walking distance between attendees, and hence the presumed pre-test perspiration and hydration status. We do not have data on the hydration status on the women, but we would expect a systematically higher Hb among women from villages distant from the clinic. Analyses of attendants at the HLH clinic showed that women from distant villages on average had 3 g/l higher Hb than women living close to the HLH (t-test, p=0.009; regression analysis 2.7 g/l, p=0.015). Dehydration may have masked anaemia in some of the women with a long walking distance. Supplementary analyses with adjustment for living place and stratification by clinic showed little effect on the associations studied in paper I-III. These analyses are not shown in the papers.

6.1.3 Considerations on some of the laboratory examinations

In the analyses of the associations between micronutrients and anaemia (Hb < 90), we found several significant associations. However, the R^2 was below 0.3 in all crude (unadjusted) analyses, meaning that the association explained less than 30% of the variation in Hb. The highest R^2 for single determinants was obtained for s-ferritin, which could explain almost a quarter of the variation in Hb (R^2=0.24). Even the full regression model with all the variables included could explain only 60 % of the variation in Hb (R^2 just below 0.6). This underscores the complicated relationship between Hb and the determinants, and warns us to be cautious about inferences on causality.

Thick blood slides for **malaria parasite** examination were prepared from capillary blood taken on the spot on the antenatal visit. The slides were prepared with Field stain and reported according to the local standard custom, number of parasites per 100 white blood cells (WBC). This is a semi-quantitative measure, and will be sensitive to changes in the total number of WBC, e.g. during a bacterial infection [113]. The parasite count (parasites per µL of blood) can be calculated in samples where the WBC count is available, using the following formula:

Parasite count = [(WBC count) x (Parasites per 100 WBC)/100] per µL

The WBC count was not available to us. There were probably few false positive readings and hence a high specificity, but there may have been a considerable number of false negative slides, since it depends on the number of fields examined, and only a limited number (20) of fields were examined. Such a misclassification may lead to some underestimation of the association with anaemia.

One out of five women had a positive malaria blood slide. However, a positive blood slide does not always imply symptomatic malaria, and a negative slide does not rule out malaria disease [64, 155-157]. The interpretation of the blood slide results may be difficult in a population of partially immune subjects, and its predictive value for malaria disease may be rather low [158, 159]. Thus, the inference we can make is only on the association between anaemia and a positive *blood slide* (read under operational conditions), not the actual association between anaemia and *malaria disease*. More sensitive indicators of malaria disease – but less specific – were the markers of hemolysis (s-LD, s-Haptoglobin, s-ferritin) and the markers of acute phase reaction (s-CRP, s-ferritin). The mechanism for this is evident from the malaria life cycle. Malaria plasmodia invade erythrocytes, mature and multiply through various stages which in the end lead to bursting of the erythrocytes and release of new parasites ready to repeat the cycle. A massive release of malaria parasites often gives rise to fever, malaise and detectable hemolysis, sometimes very severe, causing severe anaemia and jaundice, and the synchronous growth cycles may give the classic recurrent febrile attacks. Some of the new tests for malaria have a very high sensitivity and specificity for detecting malaria parasites in the blood, and are useful for tourists, but not for indigenous people. The people living in the area are semi-immune against the parasites, and may well have parasitized erythrocytes without any symptoms of disease. A continuous exposure to parasites in the blood is actually necessary to keep up the immunity against malaria. Most of the 20% of pregnant women who had a positive blood slide had no symptoms. Still, the asymptomatic malaria may have a chronic effect on the subjects, and chloroquine prophylaxis has been proven to prevent anaemia and to increase the birth weight. Chloroquine prophylaxis was used at ANC during the study. This is now abandoned due to of drug resistance. Giving presumptive treatment with sulphadoxin-pyrimetamin to pregnant women prevents severe anaemia and possibly improves neonatal survival [75]. This is currently the official policy for pregnant women in Tanzania.

The use of Norwegian normal **reference** values for biochemical examinations may not always be appropriate for use in African populations, but lacking alternative reference values, we mostly used the normal reference limits indicated by the laboratory we used in Norway. Many of these are internationally recognised reference values [114]. Where the normal reference values were disputed, we tested several cut-off values to see the effect on the associations. We could not use the distribution among the participants, because of the selection procedure.

For **vitamin A** status, we used 0.7 µmol/l as lower normal limit for s-vitamin A indicating low or borderline vitamin A status[160]. However, vitamin A below 0.35 µmol/l is often regarded as definite deficiency, and both gave similar associations with anaemia and with infections in the analyses.

The **C-reactive protein (CRP)** is an acute-phase protein that increases early during an inflammatory process. It typically increases steeply during bacterial infections, and also increases during malaria attacks[155, 161]. Viral infections usually have less impact on s-CRP, unless severe inflammation occurs. It also increases in acute inflammatory response of non-infectious origin. In high-income countries, the upper reference limit for **s**-CRP is often 10 or lower [114, 162-164], but in pregnancy, the upper reference limit may be as high as 20 mg/l [165, 166]. In many low-income countries with high exposure to infections, the reference limits may be even higher. In our study, we could not use the 2.5-97.5 percentiles of our own sample as a normal reference interval, due to the selection procedure. Since CRP was associated with anaemia, oversampling the anaemic women may have introduced a bias in the CRP distribution. However, we found that among the non-anaemic women, the mean s-CRP was 8 mg/l, the 90-centile was 15 mg/l, and the 95-centile 29 mg/l. Because of this uncertainty with normal reference limits, we analysed the association between anaemia and s-CRP with several cut-off points (5, 10, 15, and 20 mg/l), with similar results. The association had the same direction, but was stronger when using the higher cut-off values, because of a higher specificity as marker of infection, and probably also because it indicated more severe infections. In the analyses presented in paper II, we used 10 mg/l as upper limit for normal s-CRP [114, 162].

Lactate dehydrogenase (LD) is an enzyme present in all cells. The normal reference limits of LD in serum for adults are 200-450 U/l [114], corresponding well with the frequency distribution of s-LD among the study participants with Hb ≥ 110g/l. During necrosis or cell

damage (including hemolysis), the intracellular LD leaks out and the s-LD increases. Hemolysis occurs in malaria infections [64, 167], and malaria parasitaemia was common in the study population. The elevated s-LD was associated with a positive malaria blood slide, and was also highly associated with a low haptoglobin, suggesting hemolysis rather than other type of cell damage. The high correlation between s-LD and s-haptoglobin and s-ferritin is consistent with hemolysis *in vivo*, and not with hemolysis as an artefact from blood taking and handling. We therefore interpreted an elevated s-LD as a sign of hemolysis due to malaria.

Ferritin is the storage protein for iron in the cells, and can be synthesised in any cell when iron supply exceeds the demand. Plasma contains small amounts of ferritin (mostly apoferritin), but increases during cell damage and acute phase reactions. The s-ferritin correlates well with the iron stores in the body, except during acute phase reactions. Malaria attacks also increases the ferritin, and could mask an iron depletion [168, 169]. Consequently, we used different normal reference values for s-ferritin according to the s-CRP. For women with a normal s-CRP, a s-ferritin of 15 µg/l was regarded as lower limit of normal iron stores, whereas for women with s-CRP 10 and more, we used s-ferritin below 50 µg/l as lower normal reference limit [115, 170]. Transferrin receptor has been suggested as a substitute indicator for iron stores [171], but may have limitations in malarious areas [172]. S-transferrin receptor needed strict procedures for taking, separating and storing the sera, and was not available to us.

The body weight of pregnant women is subject to wide variations because of the physiological weight gains, and its usefulness as a determinant is therefore limited. However, the **arm circumference** (AC) has been shown to correlate well with pre-pregnancy body weight [173]. Some authors have drawn direct inference from a small AC to poor nutritional status [174], but it should not be done without reservations. Many factors can contribute to a slender arm in adults, including type of food, eating habits, constitution, catabolic states, and physical activity, and this may imply a low specificity for arm circumference to identify poor nutrition. Among non-anaemic women, the 10 percentile was 24 cm, 50 percentile (median) was 26 cm, and the 90 percentile was 29 cm. In our analyses, we used both 22.5 cm and 25 cm as cut-off points as suggested by Krasovec *et al.*, but in paper II the results presented were for 25 cm. Very few women had an arm circumference below 22.5 cm, and consequently even though the direction of the associations were similar, the confidence intervals were wide.

There are several laboratory methods for investigating for syphilis in serum. The **VDRL test** contains antigens produced from bovine cardiolipin, which initially proved to react strongly with syphilis antibodies, but also with many other antibodies. Cross reactions (biological false positive) have been observed in several infections, like malaria, hepatitis, brucellosis, tuberculosis, and typhoid fever, all common in the study area. In addition, rheumatic conditions may give biological false positive s-VDRL. Its advantage is that it indicates active disease, and becomes negative after the successful treatment of syphilis, unlike the specific *Treponema pallidum* tests. A study among pregnant women in Malawi indicated that more than half of the VDRL seropositives were not syphilitic. Our study area was probably comparable with Malawi as far as biological false positives concerns, although with a much lower HIV prevalence. The high proportion of positive s-VDRL probably indicates a high prevalence of both syphilis and other chronic infections. The high risk of perinatal loss for women with a positive VDRL may therefore be either due to active syphilis or to the other mentioned diseases.

The **birth weight** was only measured among the babies born at the Haydom Lutheran Hospital. Immediately after the delivery (within 30 minutes), the babies were weighed on an infant's beam-balance scale to the nearest 10 g. The birth weight was not available for home births, and the analysis of associations between anaemia and birth weight therefore included only hospital deliveries. There may be a selection bias in two opposite directions of women who deliver in the hospital: the women who are ill may be more likely to deliver in hospital, and the women who are well educated and healthy are also more likely to deliver in the hospital. The first group would have a higher than average perinatal mortality rate, the second a lower rate than average. The Hb was similar among the women delivering in hospital and the others. Further, in home births we found similar associations between perinatal mortality and babies estimated small by their mothers as the associations found in hospital deliveries between low birth weight and PMR.

6.1.4 Events during the study period

We intended to enrol women in the study for at least a year, because seasonal variations in malaria incidence were large and could influence our results. During the rainy season of 1995 there was a severe malaria epidemic in the area, causing a rise in malaria deaths in the Haydom Lutheran Hospital. Cerebral malaria also represented the majority of maternal deaths

in that period [86]. During the first half of 1995, a higher proportion of the women had detectable parasitaemia (27% versus 14%), and we also observed a lower Hb in the period (117 g/l versus 123 g/l, Fig.3, Paper III). This epidemic had a potential of greatly influencing many of our results, e.g. the PMR, associations between anaemia and CRP, ferritin, vitamin A. However, we performed supplementary analyses not presented in the papers, analysing with adjustment for season and adjustment for malaria parasitaemia, which showed little impact on statistical associations.

During 1995 and 1996, the ANC attendance increased compared to 1994 (39% and 22%, respectively). This was partly because the study project provided extra services free of charge that were not given elsewhere in the area. The presence of a doctor in some of the clinics may also have drawn some attention, especially for women with complications and questions. However, the malaria epidemic probably explains part of the increase, reflected in a more marked increase at the HLH clinic where other hospital services were available.

6.1.5 Power and significance level

We studied many potential determinants. The possibility of falsely detecting an association as significant (Type I errors) increases with the number of determinants studied. By choosing a significance level of $\alpha = 0.05$, on average one determinant in twenty (5%) will have a statistically significant association just by chance. This must be taken into account when interpreting positive findings in our material with several determinants.

The study described in paper IV had limited power (1-β) to detect weak associations with anaemia. Therefore, some associations may have been missed due to small sample size (Type II error). However, a weaker association could also indicate less clinical importance. Generally, we wanted to detect the strong and potentially *important* associations. As expected, indications of iron deficiency (low s-ferritin, s-iron, low s-Tfsat) and folic acid (low s-folate) were associated with anaemia, and also markers of infection (elevated s-CRP, elevated s-ferritin, elevated s-LD, and elevated u-nitrite).

6.2 DISCUSSION OF RESULTS

6.2.1 Perinatal and neonatal mortality rates

In the follow up, we found a perinatal mortality rate of 27/1000 births, 56% of the deaths were stillborn. The neonatal mortality rate was 17/1000 live births. There was an increased risk of perinatal death among babies with low birth weight, among babies of women with a small arm circumference, among babies of women with a positive VDRL serology, and among babies of mothers who had previously lost a baby.

The level of perinatal mortality was lower in our study than what has been reported from other East African studies (Table 8). Infant mortality has declined in many developing countries during the last decades, to a lesser degree neonatal mortality.

Two studies from East Africa (Table 8) found a remarkably low PMR: one from Machakos district in Kenya [175], the other from Iringa region in Tanzania [144].

The study in Machakos, Kenya, found surprisingly low perinatal mortality rate (46/1000), which was approximately half the national rate in Kenya at that time (1975-78). The authors found the rates almost incredible at first, but indicated several beneficial factors in this area that could explain the lower perinatal mortality: The women and children had a relatively good nutrition, breast-feeding was almost universal, malaria was not holo-endemic (though present), and medical facilities were generally available not too far away. What is not mentioned by the authors, is a possible salutary effect of the demographic surveillance system of visiting homes twice monthly. Women considered seriously ill by the field worker were referred to the project medical staff. Thus, the researchers introduced an "artificially" improved medical care, which may have had a positive effect on the outcome of pregnancy.

In Ludewe, Iringa, Tanzania, the perinatal mortality was estimated to 71/1000 in 1971-76 at Lugarawa hospital [144]. After an intervention involving changes in obstetric policies, the perinatal mortality was 39/1000. The interventions consisted of active use of partogram with more intensive monitoring of foetal heartbeats, oxytocin augmentation, more active use of assisted labour, and a routine perinatal audit. However, this study was hospital based, and registered only deaths that occurred before discharge from the hospital, and some neonatal deaths may have been missed in this way. Women with uncomplicated delivery usually go

home as soon as possible, often after 1-2 days, and if a death occurred within a week at home, some neonatal deaths would be missed. On the other hand, hospital rates usually over-estimate the community rates because of referral of risk pregnancies to hospital, and the two biases do oppose each other.

Table 8. Selected studies on perinatal and neonatal mortality in Tanzania and eastern Africa.

District, Region	Rural/ Urban	Year	Sample size	Design [1]	PMR[2]	NMR[3]	Reference
Studies from Tanzania:							
Mbulu/Hanang, Arusha	**Rural**	**1995-96**	**3618**	**P, Community**	**27**		**Paper I-II**
Mbulu/Hanang, Arusha	**Rural**	**1995-96**	**370**	**R, Community**	**38**		**Paper II**
Ludewe, Iringa	Rural	1971-76	3102	R, Hospital	71		144
Ludewe, Iringa	Rural	1977-79	1959	R, Hospital	39		144
Ilula, Iringa	Rural	1983-86	719	P, Community	82		176
Morogoro, rural	Rural	1987	3565	R, WHO survey	91		177
Kilimanjaro, rural	Rural	1987	3565	R, WHO survey	58		177
Kilombero, Morogoro	Rural	1982-88	88	P, Community	125	81	178
Kwimba, Mwanza	Rural	1989-90	3056	C-S, Hospital	96		179
Kwimba, Mwanza	Rural	1990	447	P, Community	68		180
National, Tanzania	Urban	1982-92	9238	R, Survey		52	181
	Rural					37	
National, Tanzania	Urban	1986-96	8120	R, Survey		34	182
	Rural					37	
National, Tanzania	Urban	1989-99	4029	R, Survey		52	183
	Rural					43	
Selected studies from other countries in eastern Africa:							
Machakos, Kenya	Rural	1975-78	4768	P, Community	46		175
Mangochi, Malawi	Rural	1987-90	4031	P, Community	75 [4]		184
Maputo, Mozambique	U/R	1994-95	908	P, Community	47		185
Lungwena, Malawi	Rural	1995-96	795	P, Community	65		121

[1] R= Retrospective; P= Prospective; C= Community based; H= Hospital based; C-S= Cross sectional. [2] Perinatal mortality rate = perinatal deaths per 1000 births. [3] Neonatal mortality rate = neonatal deaths per 1000 live births. [4] Rates were given separately for twins and singletons, this figure was calculated.

The level of perinatal mortality rate in our study area was unexpectedly low for a poor rural setting. Some possible explanations may be given. As pointed out in Paper I, we think very few deaths were missed because of dropouts. However, there is still a possibility of missing some attendants, see discussion in section 6.1.1.

Traditional medicine was widely used by a large proportion of people, often in conjunction with modern medicine, and the choice of healer depended on the type of disease or condition. Traditional belief was suggested to contribute to reluctance of use of modern medicine in an Ethiopian study [186], but in our study area the people usually had good faith in modern medical services and used it extensively, often in conjunction with traditional medicine. We heard about several traditional healers visiting sick people in the hospital wards. Generally, people had more faith in modern medicine in acute diseases, perhaps reflecting the obvious treatment success. Sometimes a traditional healer could cause delay in serious acute conditions, like cerebral malaria, and we recorded several histories of maternal death where the use of traditional medicine had delayed the treatment. The faith in modern medicine was also reflected in the antenatal clinic coverage above 90%, and this provided a link to the health system. The antenatal services were free, including all vaccines for mother and child, and the nurses were staff of HLH, a hospital with a good reputation.

In Tanzania, the coverage of health services seems fairly good according to government statistics, and essential and emergency obstetric services are widely distributed throughout the country. However, in many areas of Tanzania, people are not satisfied with the services at the health facilities. Quality of services is often low due to a serious lack of resources and equipment, irregular salaries and hence low working morale. The Haydom Lutheran Hospital was fortunate in this sense, with good equipment, stable supplies, regular salaries, and appropriate medical care. In addition, the hospital was involved in many development projects in the villages: building roads and bridges, water projects, agriculture, secondary schools construction, and was running a well reputed nurse and midwife training school. Therefore, the hospital had credibility for assisting the local people.

The ambulance service at the hospital was quite unique in Tanzania. Very few persons in the area had a motor vehicle, and transport to the hospital was often cumbersome. The hospital had two vehicles that were used as ambulance. They were equipped with VHF-radios linked to solar-powered radio stations in the villages. The ambulance was widely used by ordinary people, not just the most affluent. A study on the ambulance services showed that it was utilised by those who needed it most, and largely independent of socio-economic status [109]. The relatives of a patient never had to pay the transport bill immediately, but it was added to the hospital bill, giving them more time to find the money. The rapid transport to the hospital

of serious complications of pregnancy probably contributed substantially to the reduction of perinatal mortality. Similarly, the maternal mortality ratio of direct maternal deaths in this area has been shown to be lower than in other areas of Tanzania [85].

Malnutrition was not common in this area, and nutrition of women and children was fairly good. Experience from the hospital showed that cases of kwashiorkor and marasmus usually were from other districts than the study area. Breastfeeding was universal, but often they would start early with additional feeding. The first few days of life, the newborn would be given only water until the meconium had passed, then starting breast milk and cows' milk [81].

The study area was not affluent, but hunger was rare. In cases of crop failure, people would borrow from relatives or buy from other areas with better crops. This system of borrowing and lending constituted something like a social welfare system. Within the area, the distribution of health services was fairly equitable. The interviews of participants indicated that the health facilities were used both by the poor and the well-to-do.

The perinatal mortality rate of Haydom Lutheran Hospital was also lower than in many other hospital based studies in Tanzania (Fig.3, section 3.2.4), supporting the view that there is really a lower PMR in the study area. Hospital rates will normally over-estimate the community rates because of selection of complicated cases [179].

There is, however, a possibility that selection bias might have influenced the results. However, non-attendance is estimated to only around 10%. Therefore, even if the few women who never attend any modern health facility have higher risk than the rest, this would not seriously affect the results. Using retrospective data from our household study (not dependent on clinic attendance), we found a slightly higher perinatal mortality rate, but consistent with the results in Paper I. As explained earlier (section 3.2.2), the families who lose a baby are in a status of *meeta* or *metid,* which means they are stigmatized. When tracing them, the neighbours and leaders may have been reluctant to expose the problem. There may also be burial customs that preclude their exposure to "foreigners" like the investigators, making the tracing delicate and difficult.

In summary, we therefore conclude that in spite of the possibility of a slight selection bias in our study, the PMR is comparatively low.

6.2.2 Risk factors for perinatal deaths

The risk factors for perinatal death that we identified were in line with other studies in Africa. Low birth weight is recognised as the strongest predictor of perinatal death [121, 187]. A very small arm circumference below 23 cm carried a five-fold increased risk of perinatal death (Paper I). A small arm circumference may partly be due to poor nutrition of the women, partly due to heavy energy-consuming physical work. It could also be related to low socio-economic status. Adjustment with indicators of socio-economic status (cows, acreage) did not, however, remove the effect of arm circumference.

A positive VDRL showed a strong association with perinatal death. As pointed out earlier, a positive s-VDRL may not always be due to syphilis. Other chronic diseases giving a positive VDRL serology may also increase the perinatal mortality rate, notably malaria. A positive VDRL may indicate that the woman may have a treatable infection.

Women who had previously lost a child were also at increased risk of perinatal loss. It may indicate that the women have some other conditions predisposing for perinatal loss, and the health workers should always investigate further cases with a bad obstetric history, looking for infections and other treatable conditions. Clinical experience from the area taught us that some women got malaria attacks frequently during pregnancy, others almost never. Prompt treatment of malaria attacks during pregnancy may improve perinatal survival [75].

The results gave some optimism on behalf of the potential impact of the health system on the perinatal mortality. A holistic approach is important, including community and facility based health care. A credible surgical service is mandatory for the system to function.

6.2.3 Avoidability of stillbirths and neonatal deaths

The causes of death found in our study are consistent with WHO global estimates (Table 9). Infections, asphyxia related conditions and immaturity-related conditions predominate, in contrast to more affluent countries, where unavoidable deaths predominate, like congenital malformations and extreme preterm birth.

Table 9. Main causes of perinatal deaths.

Place	Year	Infection related	Immaturity related	Asphyxia related	Congenital	Other/ Unknown
Tanzania; this study	**1995-96**	**39%**	**20%**	**32%**	**7%**	**16%**
Global, WHO [188]		32%	24%	29%	10%	5%
Jamaica	1986-87	*	19%	44%	6%	32%
Bangladesh, Matlab, SB	1979-86	13%	27%	31%	*	28%
Bangladesh, Matlab, END	1979-86	10%	54%	26%	2%	7%

* Infections not specified, antepartum foetal death was 29%.

We found that approximately a quarter of the deaths could possibly have been avoided, granted that the correct steps had been taken when the condition arose. Examples of avoidable factors that might have changed the course of events, were failure to refer a woman with a risk factor to a higher level of care, doctor's failure to recognise the condition in time, failure of woman to contact the hospital when the dangers were apparent, failure to seek help because of lack of persons to take care of the home, or relatives refused the woman to go to the hospital.

Many of the deaths should in theory be easily prevented. In practice, increased alertness and a lower threshold for contacting the health services may be difficult to achieve. Certainly, with the wide coverage of the antenatal clinics, the midwives should encourage the women to have a low threshold for contacting the health services, but this may be undermined if they meet unfriendly staff when they show up. The attitude of the staff may therefore be of utmost importance.

6.2.4 Prevalence of anaemia in pregnancy

The prevalence of anaemia was lower and the average Hb was higher than in other studies from Tanzania (Table 10). The mean Hb was 12.5 as measured, and 12.1 when standardised to sea level. The proportion of women with Hb below 110 g/l was 22.7%, and standardised to sea level 36.1%, and this demonstrates how a high altitude can mask anaemia.

Table 10. Studies on the prevalence of anaemia in Tanzania.

Location	Altitude (m)*	Sample size	Gestation (weeks)	Mean Hb (g/l)	Hb<110g/l (%)	Hb<100g/l (%)	Reference
Mbulu/Hanang, rural (present study)	**13-2100**	**3836**	**16-40**	**121 (114**)**	**23%**		**Paper I**
Dar es Salaam, urban	0	1317	16-40	93	86 %	67 %	[189]
DSM; *Mbagala clinic*	0	1391	12-40	98	49%,		[190]
Kasarobo clinic		844		104	66%***		
DSM, Hai and Morogoro	0-900	257	-	100			[191]
Singida, rural	12-1500	512				11 %	[192]
Iringa, rural	1300	152	-			10 %	[193]
Zanzibar, urban	0	351		92		79 %	[72]
Arusha, urban	1000	161	-		41 %		[194]
Mpwapwa, rural	ca.1000	1148			51 %		[195]
Mpwapwa, rural	ca 1000	724	-	103-111	61 %		[196]
Moshi, urban	850	1798	≤ 20	97	75 %		[197]
Morogoro urban	600	20	28-39	87	95 %		[198]

* Meters above sea level. ** Adjusted to sea level ***cut-off 105 g/l DSM=Dar es Salaam

The differences in the prevalence of anaemia can be partly explained by the different altitudes. The study area was situated at a higher altitude, leading to a higher Hb because of the lower oxygen pressure. For example, the study in Moshi was done at a lower altitude (850 m), so a lower mean Hb would be expected (mean Hb was 96.9 g/l). Possibly, rural dwellers had better access to a varied nutrition since most of them were farmers. The other major factors affecting the Hb were gestation, malaria and season (Paper I). This is in line with other studies in the area [54, 72]. The climate is cooler than in the lowlands and less suitable for the breeding of mosquitoes, so that malaria was not holo-endemic. As expected, there was a seasonal pattern of anaemia and malaria, both more frequent in the rainy season.

The effect of other factors was smaller. We found increased risk (doubled) of anaemia among the Datoga women compared to the Iraqw women. The Datoga were more frequent in the lowlands, and adjusting for altitude and malaria parasitaemia reduced the association, but did not remove it. The difference may be due to differences in nutritional habits rather than genetic. Traditionally, the Iraqw were farmers or agropastoralists and the Datoga were cattle herders, though this pattern is less apparent nowadays, as the Datoga settle. The farming traditions may be reflected in a more varied diet for the Iraqw, particularly vegetables, which

may influence the Hb. We find support for this explanation in the material of paper IV, where a low s-folate was more common among the Datoga (30% versus 18% among the Iraqw, not shown in the papers). There was probably little difference in the general nutritional status in the two ethnic groups, since the arm circumference was not different. Other studies have also shown ethnic differences in prevalence of anaemia [199], and some authors have even advocated ethnic-specific cut-off values for anaemia [200].

There was an increased risk of anaemia with increasing parity and with increasing age (Paper III). However, after adjustment, only age was significantly associated with increased risk of anaemia. We did not find support for the theory that repeated childbearing exhausts the iron stores, but increasing age was associated with anaemia. However, the effect of age was small, Hb decreasing only 1 g/l per 5 years of age. The effect of age is actually less than the precision of the instruments, and the association seems clinically irrelevant. Other authors have found conflicting results regarding parity and anaemia, some have found an association [201, 202], others have not [199, 203-205].

6.2.5 Anaemia, infections and micronutrients

In Paper IV, the study participants were selected by their Hb level (dependent variable) into cases of varying degrees of anaemia to be compared with non-anaemic controls. Studying the associations between anaemia and background factors, it could be regarded as a modified **nested case-control** design and was analysed accordingly. The interpretations of the associations must be done with caution, keeping in mind that an observed association need not be a matter of cause and effect.

The selection procedure in paper IV aimed at approximately equal numbers in each stratum of Hb, but we did not manage to fill up the lowest stratum (Hb < 70 g/l) because of few cases. Unequal numbers were obtained in the various strata because the study was going on at several places simultaneously, and synchronization of selection was impossible. The selection resulted in (intentional) over-sampling of the lower Hb strata, and the associations with determinants were analysed like a case-control study (i.e., Hb < 90 versus Hb ≥ 110 g/l) using the odds ratio as a measure of association. Since the micronutrient status was associated with the Hb, we could not use our sample (which was selected based on Hb) to state the

"prevalence" of various micronutrient deficiencies. Instead, we indicated the proportion with low serum values among women with normal Hb, which is probably representative for non-anaemic women in the population.

Anaemia was associated with markers of infection (S-CRP, S-ferritin). A large proportion of this may be caused by malaria, which was very common in the area, and 15-20% of asymptomatic pregnant women had malaria in their blood slide. It may seem a paradox that the association with parasitaemia was not strong, but it is important to remember that a blood slide has low sensitivity and specificity for residents in areas with malaria. Actually, an elevated S-LD and a low S-haptoglobin may be more specific markers of malaria disease, as they detect minor hemolysis. The risk of anaemia among women with a high s-LD was ten-fold (Table 3, Paper IV).

Infections and malaria has great impact on the interpretation of many of the measurements we had done. In severe anaemia, infections seemed to play an even greater role. The indicators of iron status, folate status and vitamin A status may all be influenced by infections and malaria. The association with micronutrients is therefore best studied among the subjects who had no signs of infections.

Deficiencies of iron deficiency, vitamin A and folate were associated with anaemia, whereas we could not find any association with cobalamin deficiency. A recent study in Tanzania on multiple micronutrient supplementation in pregnancy improved the Hb [206]. In a recent trial from Nepal, iron and folic acid supplementation reduced low birth weight, but they did not find any additional benefit with multiple micronutrient supplementation [61]. In a large study of vitamin A supplementation, a reduction of maternal mortality was detected [207], but no influence was shown on neonatal weight nor infant mortality [208].

Previous interventions to reduce anaemia in pregnancy have included supplementation of iron and folic acid, and malaria prophylaxis. Even though proven efficacious, scarce resources and poor compliance have limited the impact of these simple and inexpensive interventions.

6.3 MAIN CONCLUSIONS AND RECOMMENDATIONS

Based on the findings in this study, we conclude as follows:

1. The perinatal mortality (PMR) in this study was lower than what has been found in other studies from Tanzania.
   This indicates that the existing health system may give better results when implemented properly, and when emergency obstetric care is quickly available.
2. Determinants associated with perinatal death were low birth weight, mother's small arm circumference, infections in mother, previous loss of baby, and primiparity. Anaemia, malaria, urinary tract infections in pregnancy were not significantly associated with perinatal death.
3. Main causes of perinatal and neonatal deaths were infection related (39%), asphyxia related (23%), and immaturity related (14%).
4. Even though the PMR was low, a quarter of the deaths could probably have been avoided either by the mother or the family, the midwife or the doctor.
   Future efforts should emphasise improving the communication at the antenatal clinics, continue preparing the women - and their families - for the delivery and to be ready for complications.
5. The prevalence of anaemia in pregnancy was substantial (36%), but lower than what has been found in other areas of Tanzania.
   The low prevalence could partly be explained by a high altitude, partly a fairly good nutrition, and partly to less prevalence of intestinal worms than many other areas in Tanzania.
6. Determinants of anaemia were high age, Datoga ethnic group, and rainy season. Furthermore, iron deficiency, folate deficiency, vitamin A deficiency, high CRP, high ferritin, high LD, malaria in blood, and u-nitrite were also related to the prevalence of anaemia, as was also an abnormally lean stature.
   Management of severe anaemia should ensure that the subject in question is not just given micronutrients, but also is examined for possible malaria or other infections.

7 References

1. Cairo Declaration on Population & Development, ICPD. International Conference of Parliamentarians on Population and Development; 1994; Cairo. WHO.
2. AbouZahr C, Wardlaw T, Stanton C, Hill K. Maternal mortality. *World Health Stat Q* 1996;49(2):77-87.
3. Murray CJ, Lopez AD. *Health dimensions of sex and reproduction*. Cambridge, Mass.: Harvard School of Public Health, 1997.
4. World Health Organization. Essential newborn care. Geneva: WHO, 1996.
5. World Health Organization. *Mother-Baby Package: Implementing safe motherhood in countries*. Geneva: WHO, 1994.
6. Loudon I. Maternal mortality in the past and its relevance to developing countries today. *Am J Clin Nutr* 2000;72(1 Suppl):241s-246s.
7. Andersson T, Högberg U, Bergström S. Community-based prevention of perinatal deaths: lessons from nineteenth-century Sweden. *Int J Epidemiol* 2000;29(3):542-548.
8. Villar J, Bergsjø P. Scientific basis for the content of routine antenatal care. I. Philosophy, recent studies, and power to eliminate or alleviate adverse maternal outcomes. *Acta Obstet Gynecol Scand* 1997;76(1):1-14.
9. Bergsjø P, Villar J. Scientific basis for the content of routine antenatal care. II. Power to eliminate or alleviate adverse newborn outcomes; some special conditions and examinations. *Acta Obstet Gynecol Scand* 1997;76(1):15-25.
10. Declaration of Alma Ata. The International Conference on Primary Health Care; 1978 Sept 12, 1978; Alma Ata. WHO.
11. Preventing the Tragedy of Maternal Death. Safe Motherhood Conference; 1987; Nairobi. WHO.
12. World Health Organization. The Safe Motherhood Action Agenda: Priorities for the next decade. Colombo, Sri Lanka: WHO, 1998.
13. The International Conference on population and Development. Programme of Action. The International Conference on population and Development (ICPD); 1994 September 5-13, 1994; Cairo. WHO.
14. Villar J, Ba'aqeel H, Piaggio G, Lumbiganon P, Miguel Belizan J, Farnot U, et al. WHO antenatal care randomised trial for the evaluation of a new model of routine antenatal care. *Lancet* 2001;357(9268):1551-64.

15. WHO, UNFPA, UNICEF, World Bank. *Reduction of maternal mortality*. Geneva: WHO, 1999.
16. Child mortality. http://www.childinfo.org/cmr/revis/db1.htm. (Accessed 18.08.03)
17. World Health Organization. WHO: recommended definitions, terminology and format for statistical tables related to the perinatal period and use of a new certificate for cause of perinatal deaths. Modifications recommended by FIGO as amended October 14, 1976. *Acta Obstet Gynecol Scand* 1977;56(3):247-53.
18. World Health Organization. *International statistical classification of diseases and related health problems, tenth revision (ICD-10)*. Geneva: WHO, 1992-1994.
19. World Health Organization. World Health Report 2000. Geneva: WHO, 2000.
20. Murray CJ, Lopez AD. Alternative projections of mortality and disability by cause 1990-2020: Global Burden of Disease Study. *Lancet* 1997;349(9064):1498-504.
21. Romero R, Gomez R, Chaiworapongsa T, Conoscenti G, Kim JC, Kim YM. The role of infection in preterm labour and delivery. *Paediatr Perinat Epidemiol* 2001;15 Suppl 2:41-56.
22. Ramakrishnan U, Manjrekar R, Rivera J, Gonzales-Cossio T, Martorell R. Micronutrients and pregnancy outcome: A review of the literature. *Nutr Res* 1999;19(1):103-159.
23. Dallman PR. Iron deficiency: does it matter? *J Intern Med* 1989;226(5):367-72.
24. Scholl TO, Hediger ML. Anemia and iron-deficiency anemia: compilation of data on pregnancy outcome. *Am J Clin Nutr* 1994;59(2 Suppl):492S-500S.
25. Loudon I. On maternal and infant mortality, 1900-1960. *Soc Hist Med* 1991;4(1):29-73.
26. World Health Organization. *Prevention and management of anaemia in pregnancy: Report of the Technical Working Group.* Geneva: WHO, 1991.
27. Armon PJ. Maternal deaths in the Kilimanjaro region of Tanzania. *Trans R Soc Trop Med Hyg* 1979;73(3):284-8.
28. AbouZahr C, Royston E. *Maternal mortality : a global factbook*. Geneva: World Health Organization, 1991.
29. Rush D. Nutrition and maternal mortality in the developing world. *Am J Clin Nutr* 2000;72(1 Suppl):212s-240s.
30. van den Broek N. Anaemia in pregnancy in developing countries. *Br J Obstet Gynaecol* 1998;105(4):385-90.
31. Steer P, Alam MA, Wadsworth J, Welch A. Relation between maternal haemoglobin concentration and birth weight in different ethnic groups. *BMJ* 1995;310(6978):489-91.

32. Steer PJ. Maternal hemoglobin concentration and birth weight. *Am J Clin Nutr* 2000;71(5):S1285-S1287.
33. Singla PN, Tyagi M, Kumar A, Dash D, Shankar R. Fetal growth in maternal anaemia. *J Trop Pediatr* 1997;43(2):89-92.
34. Garn SM, Ridella SA, Petzold AS, Falkner F. Maternal hematologic levels and pregnancy outcomes. *Semin Perinatol* 1981;5(2):155-62.
35. Brabin BJ, Ginny M, Sapau J, Galme K, Paino J. Consequences of maternal anaemia on outcome of pregnancy in a malaria endemic area in Papua New Guinea. *Ann Trop Med Parasitol* 1990;84(1):11-24.
36. Brabin B, Piper C. Anaemia- and malaria-attributable low birthweight in two populations in Papua New Guinea. *Ann Hum Biol* 1997;24(6):547-55.
37. Heilmann L, Hojnacki B, Herrle B, von Tempelhoff G, Kriechbaum A. [Hemoglobin--an obstetric risk factor]. *Geburtshilfe Frauenheilkd* 1993;53(4):235-9.
38. Murphy JF, J OR, Newcombe RG, Coles EC, Pearson JF. Relation of haemoglobin levels in first and second trimesters to outcome of pregnancy. *Lancet* 1986;1(8488):992-5.
39. Klebanoff MA, Shiono PH, Selby JV, Trachtenberg AI, Graubard BI. Anemia and spontaneous preterm birth. *Am J Obstet Gynecol* 1991;164(1):59-63.
40. Lieberman E, Ryan KJ, Monson RR, Schoenbaum SC. Risk-factors accounting for racial differences in the rate of premature birth. *N Engl J Med* 1987;317(12):743-748.
41. Lieberman E, Ryan KJ, Monson RR, Schoenbaum SC. Association of maternal hematocrit with premature labor. *Am J Obstet Gynecol* 1988;159(1):107-114.
42. Rasmussen S, Øian P. First- and second-trimester hemoglobin levels. Relation to birth weight and gestational age. *Acta Obstet Gynecol Scand* 1993;72(4):246-251.
43. Fleming AF. Tropical obstetrics and gynaecology. 1. Anaemia in pregnancy in tropical Africa. *Trans R Soc Trop Med Hyg* 1989;83(4):441-8.
44. Adams MM, Sarno AP, Harlass FE, Rawlings JS, Read JA. Risk-factors for premature delivery in a healthy cohort. *Epidemiology* 1995;6(5):525-532.
45. Rasmussen K. Is There a Causal Relationship between Iron Deficiency or Iron-Deficiency Anemia and Weight at Birth, Length of Gestation and Perinatal Mortality? *J Nutr* 2001;131(2S-2):590S-601S; discussion 601S-603S.
46. Sagen N, Nilsen ST, Kim HC, Bergsjø P, Koller O. Maternal hemoglobin concentration is closely related to birth weight in normal pregnancies. *Acta Obstet Gynecol Scand* 1984;63(3):245-8.

47. Sagen N, Koller O, Haram K. Haemoconcentration in severe pre-eclampsia. *Br J Obstet Gynaecol* 1982;89(10):802-5.
48. Carroli G, Rooney C, Villar J. How effective is antenatal care in preventing maternal mortality and serious morbidity? An overview of the evidence. *Paed Perinat Epidemiol* 2001;15:1-42.
49. World Health Organization. The prevalence of Anaemia in women: A tabulation of available information. 2.nd ed. Geneva: WHO, 1992.
50. Lund CJ, Donovan JC. Blood volume during pregnancy. Significance of plasma and red cell volumes. *Am J Obstet Gynecol* 1967;98(3):394-403.
51. Koller O. The clinical significance of hemodilution during pregnancy. *Obstet Gynecol Surv* 1982;37(11):649-52.
52. Royston E. The prevalence of nutritional anaemia in women in developing countries: a critical review of available information. *World Health Stat Q* 1982;35(2):52-91.
53. Milman N, Bergholt T, Byg KE, Eriksen L, Graudal N. Iron status and iron balance during pregnancy. A critical reappraisal of iron supplementation. *Acta Obstet Gynecol Scand* 1999;78(9):749-757.
54. Massawe SN, Urassa EN, Mmari M, Ronquist G, Lindmark G, Nystrom L. The complexity of pregnancy anemia in Dar-es-Salaam. *Gynecol Obstet Invest* 1999;47(2):76-82.
55. Suharno D, West CE, Muhilal, Karyadi D, Hautvast JG. Supplementation with vitamin A and iron for nutritional anaemia in pregnant women in West Java, Indonesia. *Lancet* 1993;342(8883):1325-8.
56. Stephensen CB, Alvarez JO, Kohatsu J, Hardmeier R, Kennedy JI, Gammon RB. Vitamin-A is excreted in the urine during acute infection. *Am J of Clin Nutr* 1994;60(3):388-392.
57. Lumley J, Watson L, Watson M, Bower C. Periconceptional supplementation with folate and/or multivitamins for preventing neural tube defects (Cochrane Review). *Cochrane Database Syst Rev* 2001;3.
58. Scholl TO, Johnson WG. Folic acid: influence on the outcome of pregnancy. *Am J Clin Nutr* 2000 May;71(5 Suppl):1295s-303s.
59. van den Broek NR, Letsky EA. Etiology of anemia in pregnancy in south Malawi. *Am J Clin Nutr* 2000;72(1 Suppl):247s-256s.
60. United Nations Children's Fund, World Health Organisation, United Nations University. Composition of a Multi-micronutrient supplements to be used in pilot programmes

among for pregnant women in developing countries. New York: UNICEF/WHO/UNU, 1999.

61. Christian P, Khatry SK, Katz J, Pradhan EK, LeClerq SC, Shrestha SR, et al. Effects of alternative maternal micronutrient supplements on low birth weight in rural Nepal: double blind randomised community trial. *Bmj* 2003;326(7389):571.
62. Kurtzhals JA, Rodrigues O, Addae M, Commey JO, Nkrumah FK, Hviid L. Reversible suppression of bone marrow response to erythropoietin in Plasmodium falciparum malaria. *Br J Haematol* 1997;97(1):169-74.
63. Rougemont A, Dumbo O, Bouvier M, Soula G, Perrin L, Tamoura B, et al. Hypohaptoglobinaemia as an epidemiological and clinical indicator for malaria. Results of two studies in a hyperendemic region in West Africa. *Lancet* 1988;2(8613):709-12.
64. Jakobsen PH, Bygbjerg IC, Theander TG, Hviid L, Fujioka H, Aikawa M, et al. Soluble haemoglobin is a marker of recent Plasmodium falciparum infections. *Immunol Lett* 1997;59(1):35-42.
65. Font F, Alonso Gonzalez M, Nathan R, Lwilla F, Kimario J, Tanner M, et al. Maternal mortality in a rural district of southeastern Tanzania: an application of the sisterhood method. *Int J Epidemiol* 2000;29(1):107-12.
66. Hinderaker SG, Kruger C, Olsen BE, Naman N, Bergsjø P, Olsen OH. Low HIV-seroprevalence in pregnant women in a rural area in Tanzania. *Acta Obstet Gynecol Scand* 2001;80(12):1152-3.
67. Ndyomugyenyi R, Magnussen P. Anaemia in pregnancy: Plasmodium falciparum infection is an important cause in primigravidae in Hoima district, western Uganda. *Ann Trop Med Parasitol* 1999;93(5):457-65.
68. Shulman CE, Graham WJ, Jilo H, Lowe BS, New L, Obiero J, et al. Malaria is an important cause of anaemia in primigravidae: evidence from a district hospital in coastal Kenya. *Trans R Soc Trop Med Hyg* 1996;90(5):535-9.
69. Hinderaker SG, Olsen BE, Lie RT, Bergsjø PB, Gasheka P, Bondevik GT, et al. Anemia in pregnancy in rural Tanzania: associations with micronutrients status and infections. *Eur J Clin Nutr* 2002;56(3):192-9.
70. Phillips RE, Pasvol G. Anaemia of Plasmodium falciparum malaria. *Baillieres Clin Haematol* 1992;5(2):315-30.

71. Garner P, Brabin B. A review of randomized controlled trials of routine antimalarial drug prophylaxis during pregnancy in endemic malarious areas. *Bull World Health Organ* 1994;72(1):89-99.
72. Matteelli A, Donato F, Shein A, Muchi JA, Leopardi O, Astori L, et al. Malaria and anaemia in pregnant women in urban Zanzibar, Tanzania. *Ann Trop Med Parasitol* 1994;88(5):475-83.
73. Fleming AF. The aetiology of severe anaemia in pregnancy in Ndola, Zambia. *Ann Trop Med Parasitol* 1989;83(1):37-49.
74. Mahomed K. Iron supplementation in pregnancy. *Cochrane Database Syst Rev* 2000(2):Cd000117.
75. Shulman CE, Dorman EK, Cutts F, Kawuondo K, Bulmer JN, Peshu N, et al. Intermittent sulphadoxine-pyrimethamine to prevent severe anaemia secondary to malaria in pregnancy: a randomised placebo-controlled trial. *Lancet* 1999;353(9153):632-636.
76. Lengeler C. Insecticide-treated bednets and curtains for preventing malaria. *Cochrane Database Syst Rev* 2000;2.
77. Viteri FE. Iron supplementation for the control of iron deficiency in populations at risk. *Nutr Rev* 1997;55(6):195-209.
78. Massawe SN, Urassa EN, Nystrom L, Lindmark G. Effectiveness of primary level antenatal care in decreasing anemia at term in Tanzania. *Acta Obstet Gynecol Scand* 1999;78(7):573-579.
79. Blystad A. The pastoral Barabaig : fertility, recycling and the social order [Master degree thesis]. University of Bergen, 1992.
80. Rekdal OBr. Kulturell kontinuitet og sosial endring. En studie av iraqw-folket i det nordlige Tanzania. [Change and continuity in Iraqw society and culture] [Master degree thesis]. University of Bergen, 1991.
81. Blystad A. Precarious procreation : Datoga pastoralists at the late 20th century [Dr.polit.thesis]. University of Bergen, 2000.
82. Rekdal OB. The invention by tradition : creativity and change among the Iraqw of northern Tanzania [Dr.polit.thesis]. University of Bergen, 1999.
83. Olsen BE. Motherhood - a hazardous endeavour. Maternal deaths and urinary tract infections in pregnancy in rural northern Tanzania [Dr.Med.]. University of Bergen, 2002.

84. Olsen BE, Hinderaker SG, Kazaura M, Lie RT, Bergsjø P, Gasheka P, et al. Estimates of maternal mortality by the sisterhood method in rural northern Tanzania: a household sample and an antenatal clinic sample. *BJOG* 2000;107(10):1290-7.
85. Olsen BE, Hinderaker SG, Lie RT, Bergsjø P, Gasheka P, Kvale G. Maternal mortality in northern rural Tanzania: assessing the completeness of various information sources. *Acta Obstet Gynecol Scand* 2002;81(4):301-7.
86. Olsen BE, Hinderaker SG, Bergsjo P, Lie RT, Olsen OH, Gasheka P, et al. Causes and characteristics of maternal deaths in rural northern Tanzania. *Acta Obstet Gynecol Scand* 2002;81(12):1101-9.
87. Olsen BE, Hinderaker SG, Lie RT, Gasheka P, Bærheim A, Bergsjø P, et al. The diagnosis of urinary tract infections among pregnant women in rural Tanzania; prevalences and correspondence between different diagnostic methods. *Acta Obstet Gynecol Scand* 2000;79(9):729-36.
88. Government of Tanzania. Health statistics abstract. Dar es Salaam: Ministry of Health [Tanzania], 2001.
89. World Bank. *Tanzania at the turn of the century : from reforms to sustained growth and poverty reduction*. Washinton, D.C.: World Bank, 2001.
90. The National Bureau of Statistics T. 2002 Population and housing census. General report. Dar es Sallam: The National bureau of Statistics, 2002.
91. World Health Organization. World Health Report 2001. Geneva: WHO, 2001.
92. http://www.tanzania.go.tz/statisticsf.html. (Accessed 26.06.03)
93. World Bank. *World development indicators*. Washington D.C.: World Bank.
94. http://www.tanzania.go.tz/healthf.html. (Accessed 20.08.03)
95. Health Sector Reforms. http://www.mof.go.tz/healthf.html. (Accessed 260102)
96. http://www.mara.org.za. (Accessed 10.08.03)
97. Rekdal OB. Money, milk, and sorghum beer: Change and continuity among the Iraqw of northern Tanzania. *Africa* 1996;66(3):367-385.
98. Rekdal OB. Cross-cultural healing in east African ethnography. *Med Anthropol Q* 1999;13(4):458-82.
99. Rekdal OB, Blystad A. 'We are as sheep & goats' : Iraqw & Datooga discourses on fortune, failure & the future. In: Anderson DM, Broch-Due V, editors. *"The poor are not us": Poverty and pastoralism in Eastern Africa*. Oxford: James Curry, 1999:125-146.

100. Blystad A. "Do Give us Children": The Problem of Fertility among the Pastoral Barbayiig of Tanzania. In: Ahmed AGM, Abdel HA, editors. *Manaaging Scarcity: Human Adaptation in East African Drylands*. Addis Ababa: Commercial Printing Enterprise, 1996.

101. Blystad A. *Vanishing tombs, barren wombs : confrontation between pastoral Datooga women and commercial cultivators in Northern Tanzania*. London: Iied, 1998.

102. Blystad A. "Dealing with men's spears": Datooga pastoralists combating male intrusion on female fertility. In: Kaare B, Sanders T, Moore HL, editors. *Those who play with fire : gender, fertility and transformation in East and Southern Africa. London School of Economics monographs on social anthropology ; 69*. London: Athlone Press, 1999:IX, 310 s.

103. Blystad A. Challenging encounters : Datoga lives in independent Tanzania. In: Manger L, Ahmed AGM, editors. *Pastoralists and environment : experiences from the Greater Horn of Africa : proceedings of the regional workshops on African drylands, Addis Ababa and Jinja / edited by*. Addis Abeba: Organization for Social Science Research in Eastern and Southern Africa (OSSREA), 2000:S. 157-180.

104. Bergsjo P. African intermezzo. Home birth, Masai style [editorial]. *Acta Obstet Gynecol Scand* 1993;72(8):597-8.

105. Bura M. Pregnancy and child rearing practices among the Wa-iraqw of Tanzania [Diploma]. Liverpool School of Tropical Medicine, 1984.

106. Selvik E. *Channelling flows of blood and water : a study of gender, fertility and seclusion practices among Iraqw people in Tanzania*. Oslo: Universitetet, 1998.

107. World Health Organisation. Essential obstetric care. Geneva: WHO, 2000.

108. Meindertsma JD, Kessler JJ. Towards better use of environmental resources. A planning document of Karatu and Mbulu districts, Tanzania. Mbulu: Mbulu district council, 1997.

109. Lervik O, Kvåle G, Hinderaker SG, Olsen BE. Too far to walk. A study of the ambulance service in the Haydom area [Undergraduate medical school]. Bergen, 2001.

110. Haydom Lutheran Hospital. Haydom Lutheran Hospital. Annual report 1995. Haydom: Haydom Lutheran Hospital, 1996.

111. World Health Organisation. Report on the global HIV/AIDS epidemic 2002. Barcelona, 2002.

112. Simon V. Local culture: risk or resource in times of AIDS? : a case study from Mbulu in northern Tanzania [Master degree thesis]. Bergen, 2002.

113. Cheesbrough M. *District laboratory practice in tropical countries*. Low priced edition ed. Cambridge: Tropical Health Technology, 1999.

114. Brekke T. *[User's handbook. A laboratory requisition guide. Haukeland hospital]*. Bergen: Laser Sats DTP AS, 1997.

115. Cook JD, Skikne BS. Iron deficiency: definition and diagnosis. *J Intern Med* 1989;226(5):349-55.

116. Mirza NM, Macharia WM, Wafula EM, Agwanda RO, Onyango FE. Verbal autopsy: a tool for determining cause of death in a community. *East Afr Med J* 1990;67(10):693-8.

117. Hoj L, Stensballe J, Aaby P. Maternal mortality in Guinea-Bissau: the use of verbal autopsy in a multi-ethnic population. *Int J Epidemiol* 1999;28(1):70-6.

118. CDC. CDC criteria for anemia in children and childbearing-aged women. *MMWR Morb Mortal Wkly Rep* 1989;38(22):400-4.

119. Dirren H, Logman MH, Barclay DV, Freire WB. Altitude correction for hemoglobin. *Eur J Clin Nutr* 1994;48(9):625-32.

120. Osman NB, Challis K, Cotiro M, Nordahl G, Bergstrom S. Maternal and fetal characteristics in an obstetric cohort in Mozambique. *Afr J Reprod Health* 2000;4(1):110-9.

121. Kulmala T, Vaahtera M, Ndekha M, Koivisto AM, Cullinan T, Salin ML, et al. The importance of preterm births for peri- and neonatal mortality in rural Malawi. *Paed Perinat Epidemiol* 2000;14(3):219-26.

122. Mulder MB. Demography of Pastoralists: Preliminary data on the Datoga of Tanzania. *Human Ecology* 1992;20(4):383-405.

123. World Health Organization, The Johns Hopkins School of Hygiene and Public Health, The London School of Hygiene and Tropical Medicine. A standard Verbal Autopsy Method for Investigating Causes of Death in Infants and Children. Geneva: WHO, 1999.

124. Smith PG, Morrow RH. *Methods for field trials of interventions against tropical diseases*. New York: Oxford University Press Inc., 1991.

125. Nykanen M, Tamaona W, Cullinan T, Van Oosterzee V, Ashorn P. Verbal autopsy as a technique to establish causes of infant and child mortality. *East Afr Med J* 1995;72(11):731-4.

126. Snow RW, Armstrong JR, Forster D, Winstanley MT, Marsh VM, Newton CR, et al. Childhood deaths in Africa: uses and limitations of verbal autopsies. *Lancet* 1992;340(8815):351-355.

127. Mobley CC, Boerma JT, Titus S, Lohrke B, Shangula K, Black RE. Validation study of a verbal autopsy method for causes of childhood mortality in Namibia. *J Trop Pediatr* 1996;42(6):365-9.

128. Anker M. The effect of misclassification error on reported cause-specific mortality fractions from verbal autopsy. *Int J Epidemiol* 1997;26(5):1090-6.

129. Bang AT, Bang RA. Diagnosis of causes of childhood deaths in developing countries by verbal autopsy: suggested criteria. The SEARCH Team. *Bull World Health Organ* 1992;70(4):499-507.

130. Cole S, Hartford RB, Bergsjø P, McCarthy B. International collaborative effort (ICE) on birth weight, plurality, perinatal, and infant mortality. III: A method of grouping underlying causes of infant death to aid international comparisons. *Acta Obstet Gynecol Scand* 1989;68(2):113-117.

131. Wigglesworth JS. Monitoring perinatal mortality. A pathophysiological approach. *Lancet* 1980;2(8196):684-686.

132. Snow RW, Basto de Azevedo I, Forster D, Mwankuyse S, Bomu G, Kassiga G, et al. Maternal recall of symptoms associated with childhood deaths in rural east Africa. *Int J Epidemiol* 1993;22(4):677-83.

133. Kalter HD, Gray RH, Black RE, Gultiano SA. Validation of postmortem interviews to ascertain selected causes of death in children. *Int J Epidemiol* 1990;19(2):380-6.

134. Coria Soto I, Zambrana Castaneda M, Reyes Zapata H, Salinas Martinez AM. Comparison of two methods for the discrimination of avoidable perinatal deaths. *J Perinat Med* 1997;25(2):205-12.

135. Langhoff Roos J, Borch Christensen H, Larsen S, Lindberg B, Wennergren M. Potentially avoidable perinatal deaths in Denmark and Sweden 1991. *Acta Obstet Gynecol Scand* 1996;75(9):820-5.

136. Mercon de Vargas PR. Avoidable infant and perinatal deaths? *Lancet* 2000;356.

137. De Reu PA, Nijhuis JG, Oosterbaan HP, Eskes TK. Perinatal audit on avoidable mortality in a Dutch rural region: a retrospective study. *Eur J Obstet Gynecol Reprod Biol* 2000;88(1):65-9.

138. Myers SA, Fisher DE, Moawad A, Paton JB, Lee KS, Ferguson M. Assessment of potentially avoidable perinatal mortality in a regionalized program. *J Reprod Med* 1990;35(1):29-34.

139. Wilkinson D. Reducing perinatal mortality in developing countries. *Health Policy Plan* 1997;12(2):161-165.

140. Theron GB. The potential of midwives providing primary obstetric care to reduce perinatal deaths in a rural region. *Int J Gynaecol Obstet* 2000 Sep;70(3):367-71.

141. Pattinson RC, Makin JD, Shaw A, Delport SD. The value of incorporating avoidable factors into perinatal audits. *S Afr Med J* 1995;85(3):145-147.

142. Ward HR, Howarth GR, Jennings OJ, Pattinson RC. Audit incorporating avoidability and appropriate intervention can significantly decrease perinatal mortality. *S Afr Med J* 1995;85(3):147-150.

143. Rotchford K, Lombard C, Zuma K, Wilkinson D. Impact on perinatal mortality of missed opportunities to treat maternal syphilis in rural South Africa: baseline results from a clinic randomized controlled trial. *Trop Med Int Health* 2000;5(11):800-804.

144. van Roosmalen J. Perinatal mortality in rural Tanzania. *BJOG* 1989;96(7):827-834.

145. De Muylder X. Perinatal mortality audit in a Zimbabwean district. *Paediatr Perinat Epidemiol* 1989;3(3):284-293.

146. Grech ES. Obstetric deaths in Lusaka. *Med J Zambia* 1978;12(2):45-53.

147. Jahn A, Kowalewski M, Kimatta SS. Obstetric care in southern Tanzania: does it reach those in need? *Trop Med Int Health* 1998;3(11):926-932.

148. Jahn A, Dar Iang M, Shah U, Diesfeld HJ. Maternity care in rural Nepal: a health service analysis. *Trop Med Int Health* 2000;5(9):657-665.

149. Haram K, Hervig T, Ulvik RJ. [Hemoglobin, iron deficiency and anemia in pregnant women. Diagnostic aspects]. *Tidsskr Nor Laegeforen* 1997;117(7):962-6.

150. Hudson Thomas M, Bingham KC, Simmons WK. An evaluation of the HemoCue for measuring haemoglobin in field studies in Jamaica. *Bull World Health Organ* 1994;72(3):423-6.

151. HemoCue B-Hemoglobin. http://www.hemocue.com/hemocueint/sida_55.asp. (Accessed 16.8.2003)

152. Cohen AR, Seidl-Friedman J. HemoCue system for hemoglobin measurement. Evaluation in anemic and nonanemic children. *Am J Clin Pathol* 1988;90(3):302-5.

153. Chen PP, Short TG, Leung DH, Oh TE. A clinical evaluation of the Hemocue haemoglobinometer using capillary, venous and arterial samples. *Anaesth Intensive Care* 1992;20(4):497-500.

154. Conway AM, Hinchliffe RF, Earland J, Anderson LM. Measurement of haemoglobin using single drops of skin puncture blood: is precision acceptable? *J Clin Pathol* 1998;51(3):248-50.

155. Hurt N, Smith T, Teuscher T, Tanner M. Do high levels of C-reactive protein in Tanzanian children indicate malaria morbidity. *Clin Diagn Lab Immunol* 1994;1(4):437-44.

156. Bouvier P, Rougemont A, Breslow N, Doumbo O, Delley V, Dicko A, et al. Seasonality and malaria in a west African village: does high parasite density predict fever incidence? *Am J Epidemiol* 1997;145(9):850-7.

157. Manson-Bahr PEC, Bell DR. *Manson's Tropical Diseases*. 11 ed. London: Bailliere Tindall, 1987.

158. Delley V, Bouvier P, Breslow N, Doumbo O, Sagara I, Diakite M, et al. What does a single determination of malaria parasite density mean? A longitudinal survey in Mali. *Trop Med Int Health* 2000;5(6):404-12.

159. Kilian AH, Metzger WG, Mutschelknauss EJ, Kabagambe G, Langi P, Korte R, et al. Reliability of malaria microscopy in epidemiological studies: results of quality control. *Trop Med Int Health* 2000;5(1):3-8.

160. Arroyave G, Chichester C, Flores H. *Methodologies for monitoring and evaluating vitamin A deficiency intervention programs : a report of the International Vitamin A Consultative Group (IVACG)*. Washington, D.C.: IVACG, 1989.

161. Eriksson B, Hellgren U, Rombo L. Changes in erythrocyte sedimentation rate, C-reactive protein and hematological parameters in patients with acute malaria. *Scand J Infect Dis* 1989;21(4):434-41.

162. Erlandsen EJ, Randers E. Reference interval for serum C-reactive protein in healthy blood donors using the Dade Behring N Latex CRP mono assay. *Scand J Clin Lab Invest* 2000;60(1):37-43.

163. Kindmark C-O. The concentration of C-reactive protein in sera from healthy individuals. *Scand J Clin Lab Invest* 1972;29:407-411.

164. Romem Y, Artal R. C-reactive protein in pregnancy and in the postpartum period. *Am J Obstet Gynecol* 1985;151(3):380-3.

165. Nielsen FR, Bek KM, Rasmussen PE, Qvist I, Tobiassen M. C-reactive protein during normal pregnancy. *Eur J Obstet Gynecol Reprod Biol* 1990;35(1):23-7.

166. Kuvibidila S, Warrier RP, Yu L, Ode D, Mbele V. Reference levels of acute phase reactant proteins in healthy Zairean women in the reproductive age group. *J Trop Med Hyg* 1994;97(4):239-43.

167. Klenerman P, Dickson H, Luzzi GA. Plasma lactate dehydrogenase estimation in the diagnosis of malaria. *Ann Trop Med Parasitol* 1992;86(5):563-5.

168. Kuvibidila S, Yu L, Warrier RP, Ode D, Mbele V. Usefulness of serum ferritin levels in the assessment of iron status in non-pregnant Zairean women of childbearing age. *J Trop Med Hyg* 1994;97(3):171-9.

169. Kuvibidila S, James M, Warrier R, Ode D, Yu LL, Tshefu KA. Plasma ferritin levels in Zairan children with severe, moderate and asymptomatic malaria. *Pediatric Research* 1994;35(4):A163.

170. World Health Organization. Report of the African Regional Consultation on Control of Anaemia in Pregnancy. Geneva: WHO, 1989.

171. Kuvibidila S, Mark JA, Warrier RP, Yu L, Ode D, Tshefu KA. Soluble transferrin receptor as an index of iron status in Zairian children with malaria. *J Trop Med Hyg* 1995;98(6):373-8.

172. Beesley R, Filteau S, Tomkins A, Doherty T, Ayles H, Reid A, et al. Impact of acute malaria on plasma concentrations of transferrin receptors. *Trans R Soc Trop Med Hyg* 2000 May-Jun;94(3):295-8.

173. Krasovec K. Part IV: Arm circumference. In: Krasovec K, Anderson MA, editors. *Maternal nutrition and pregnancy outcome. Anthropometric assessment*. Washington DC: Pan American Health Organization, 1991:119-131.

174. Liljestrand J, Bergstrom S. Antenatal nutritional assessment: the value of upper arm circumference. *Gynecol Obstet Invest* 1991;32(2):81-3.

175. Voorhoeve AM, Muller AS, W'oigo H. The outcome of pregnancy. In: van Ginneken JK, Muller AS, editors. *Maternal and child health in rural Kenya*. London: Croom Helm Ltd, 1984.

176. Möller B, Lushino O, Kabukoba J, Kavishe F, Gebre Medhin M, Meirik O, et al. A prospective area-based study of the outcome of pregnancy in rural Tanzania. *Ups J Med Sci* 1989;94(1):101-109.

177. Kitange H, Swai AB, Masuki G, Kilima PM, Alberti KG, McLarty DG. Perinatal mortality in rural Tanzania. *World Health Forum* 1994;15(1):82-4.

178. Tanner M, de Savigny D, Mayombana C, Hatz C, Burnier E, Tayari S, et al. Chapter 19: Morbidity and mortality at Kilombero, Tanzania, 1982-88. In: Feachem RG, Jamison DT, editors. *Disease and mortality in Sub-Saharan Africa*. Washington DC: World Bank, 1991:286-305.

179. Walraven GE, Mkanje RJ, van Roosmalen J, van Dongen PW, Dolmans WM. Comparison of perinatal outcome in rural Tanzania as obtained from a prospective community-based survey and hospital data. *Trop Geogr Med* 1994;46(1):11-13.

180. Walraven GE, Mkanje RJ, Roosmalen J, van Dongen PW, Dolmans WM. Perinatal mortality in home births in rural Tanzania. *Eur J Obstet Gynecol Reprod Biol* 1995;58(2):131-4.

181. National Bureau of Statistics [Tanzania] and Macro International Inc. Tanzania Demographic and Health Survey 1991/1992. Columbia, Maryland: National Bureau of Statistics [Tanzania] and Macro International Inc., 1993:306.

182. National Bureau of Statistics [Tanzania] and Macro International Inc. Tanzania Demographic and Health Survey 1996. Calverton, Maryland: National Bureau of Statistics [Tanzania] and Macro International Inc., 1997:312.

183. National Bureau of Statistics T, Inc. MI. Tanzania Reproductive and Child Health Survey 1999. Calverton, Maryland: National Bureau of Statistics [Tanzania] and Macro International Inc., 2000:230.

184. McDermott JM, Steketee R, Wirima J. Mortality associated with multiple gestation in Malawi. *Int J Epidemiol* 1995;24(2):413-9.

185. Osman NB, Challis K, Cotiro M, Nordahl G, Bergstrom S. Perinatal outcome in an obstetric cohort of Mozambican women. *J Trop Pediatr* 2001;47(1):30-8.

186. Shamebo D. Mothers' perceived cause of death: a survey of infant mortality in Butajira, Ethiopia. *Ethiopian Journal of Health and Development* 1990;4(1):15-20.

187. Wilcox AJ. On the importance--and the unimportance--of birthweight. *Int J Epidemiol* 2001;30(6):1233-41.

188. Save the Children. State of the world's newborns. Report 2001. Westport, Connecticut: Save the Children, 2001.

189. Mwanukuzi E, Nhonoli AM. Anaemia in expectant mothers. *East Afr Med J* 1972;49(2):101-7.

190. Massawe S, Urassa E, Lindmark G, Moller B, Nystrom L. Anaemia in pregnancy: A major health problem with implications for maternal health care. *African Journal of Health Sciences* 1996;3(4):126-32.

191. Kitange HM, Swai A, Kilima PM, Masuki G, Alberti KGMM, McLarty DG. Anemia is a major public-health problem in Tanzania. *Health Policy and Planning* 1993;8(4):413-424.

192. Maseu G. Anaemia in Pregnancy in Singida. [Master of Medicine Dissertation]. MUCHS, Dar es Salaam, 1986.

193. Möller B, Lushino O, Meirik O, Gebre Medhin M, Lindmark G. A study of antenatal care at village level in rural Tanzania. *Int J Gynaecol Obstet* 1989;30(2):123-31.

194. Kipuyo E. Factors associated with Prevalence of Anaemia among the general population in Arusha Comunipality - 1993. [Master of Medicine Dissertation.]. MUCHS, Dar es Salaam, 1994.

195. Msafiri P. Anaemia in pregnancy and Associated Factors in Mpwapwa District Hospital. [Master of Medicine Dissertation, Obs&Gyn]. MUCHS, Dar es Salaam, 1987.

196. Tumbo A. Maternal Anaemia and associated factors in Mpwapwa District, Tanzania. [Master of Medicine Dissertation]. MUCHS, Dar es Salaam, 1994.

197. Bergsjø P, Seha AM, Ole King'ori N. Hemoglobin concentration in pregnant women. Experience from Moshi, Tanzania. *Acta Obstet Gynecol Scand* 1996;75(3):241-4.

198. Msolla MJ, Kinabo JL. Prevalence of anaemia in pregnant women during the last trimester. *Int J Food Sci Nutr* 1997;48(4):265-70.

199. Bondevik GT, Ulstein M, Lie RT, Rana G, Kvale G. The prevalence of anemia in pregnant Nepali women--a study in Kathmandu. *Acta Obstet Gynecol Scand* 2000 May;79(5):341-9.

200. Johnson Spear MA, Yip R. Hemoglobin difference between black and white women with comparable iron status: justification for race-specific anemia criteria [see comments]. *Am J Clin Nutr* 1994;60(1):117-21.

201. Ogbeide O, Wagbatsoma V, Orhue A. Anaemia in pregnancy. *East Afr Med J* 1994;71(10):671-3.

202. Jackson DJ, Klee EB, Green SD, Mokili JL, Elton RA, Cutting WA. Severe anaemia in pregnancy: a problem of primigravidae in rural Zaire. *Trans R Soc Trop Med Hyg* 1991;85(6):829-32.

203. Thomson J. Anaemia in pregnant women in eastern Caprivi, Namibia. *S Afr Med J* 1997;87(11):1544-7.

204. Khan KS, Chien PFW, Khan NB. Nutritional stress of reproduction - A cohort study over two consecutive pregnancies. *Acta Obstet Gynecol Scand* 1998;77(4):395-401.

205. Coulibaly M, Costagliola D, Zittoun J, Mary JY. Modifications of hemato-biological parameters in pregnant women in a migrating population in northern Cameroon: prevalence of anemia, iron and folates deficiencies. *Int J Vitam Nutr Res* 1987;57(2):173-8.

206. Makola D, Ash DM, Tatala SR, Latham MC, Ndossi G, Mehansho H. A micronutrient-fortified beverage prevents iron deficiency, reduces anemia and improves the hemoglobin concentration of pregnant tanzanian women. *J Nutr* 2003;133(5):1339-46.

207. West KP, Katz J, Khatry SK, LeClerq SC, Pradhan EK, Shrestha SR, et al. Double blind, cluster randomised trial of low dose supplementation with vitamin A or beta carotene on mortality related to pregnancy in Nepal. The NNIPS-2 Study Group. *BMJ* 1999;318(7183):570-5.

208. Katz J, West KP, Khatry SK, Pradhan EK, LeClerq SC, Christian P, et al. Maternal low-dose vitamin A or beta-carotene supplementation has no effect on fetal loss and early infant mortality: a randomized cluster trial in Nepal. *Am J Clin Nutr* 2000 Jun;71(6):1570-6.

8 Appendices

The questionnaires for the research were written in Swahili, but are here reproduced in English versions.
Research permit in Tanzania was given for one calendar year, only the first permit is shown here. Also, the clearances at regional level and district level are not shown here.

Questionnaires:

- Questionnaire for antenatal visit
- Questionnaire for visit after delivery
- Questionnaire for verbal autopsy for deceased infants

Research clearances

- Research permit, Tanzania, COSTECH
- Ethical clearance of research, Norway

8.1 QUESTIONNAIRE FOR ANTENATAL VISIT

1. All information is to be kept confidential by interviewer and anyone who is involved in the project.
2. If the respondent refuses to answer the questionnaire, please write this on the front page. If the respondent refuses to answer specific questions, please write an R in the right margin beside the specific question.

ANTENATAL CLINIC SURVEY

To be filled in for women attending antenatal care and who are included in the Urinary Tract Infection and Anaemia studies.

Is willing to answer questionnaire:Yes:___ No:____

If not willing, please enter all information up till Q.3

Date of interview:_____

Name of interviewer: _____

Place of interview (MCH clinic): _____

MCH clinic registration number:_____

1. Mother`s name:_____ Clan:_____
2. Mother's tribe:_____ Religion:_____
3. Mother`s address: Ten-cell leader:_____
   Kitongoji (place):_____ Village:_____
   Ward:_____
4. Mother's age in completed years:_____ (Tick one of the following).
   ____ Age based on date of year of birth
   ____ Age based on estimate
5. Mother's place of birth: Village:_____Ward:_____
6. Does the mother wear a "hanang'wenda" (skin skirt)? Yes:____ No:____

7. Husband`s name: _____Clan:_____
8. Husband's tribe:_____Religion:_____
9. Husband`s address if different from above:
   Ten-cell leader:_____
   Kitongoji(place):_____ Village:_____
   Ward:_____

EDUCATION / OCCUPATION

1. Completed years of education:

Male	Female	
_____	_____	Primary:
_____	_____	Secondary:
_____	_____	Training of other types:

Yes	No	Yes	No	
___	___	___	___	Can you read?
___	___	___	___	Can you write?

2. What types of work is done to earn money for the family? (Several ticks may be made.)

Male		Female		
Yes	No	Yes	No	
___	___	___	___	Farmer
___	___	___	___	Keeping Livestock
___	___	___	___	Brewing beer
___	___	___	___	Owner of business: Specify:_____
___	___	___	___	Employed in business: Specify: _____
___	___	___	___	Employed in other institution; Specify type: _____
___	___	___	___	Not employed, and looking for employment:
___	___	___	___	Student:
___	___	___	___	Other ways of getting money, specify:_____

3. Does the mother have any income other than the husband's? Yes___ No___

If YES, please specify:_____

HOUSEHOLD/SANITATION/INCOME/TRANSPORT

1. In the household where you are living how many are there of the following?

Number	
____	Cattle
____	Goats
____	Sheep
____	Pigs
____	Chicken
____	Ducks
____	Others; specify _____

2. How many acres of shamba does the family of this household have? _____

3. What is grown on these acres?

Acres

____ Maize:

____ Wheat:

____ Millet:

____ Beans:

____ Sunflower:

____ Vegetables:

____ Other:(specify:_____

4. How many of these acres are grown for household use only? _____

5. How many of these acres are grown for sale? _____

6. Does the household have enough food for their own needs? Yes___ No___

7. If no, what do they do when they need extra food? Specify:_____

8. How many houses does the family have to live in at your dwelling place? __

9. What type of housing is the residence where you sleep?

a) Walls:

____ Mud/earth

____ Straw

____ Bricks

____ Cement

____ Other; specify:_____

b) Roof:

____ Bati

____ Straw

____ Earth

____ Other; specify: _____

10. Number of rooms in your residence where you sleep: _____

11. Do cows and other livestock stay in your main house where you sleep at night? Yes___ No___

12. Are there ticks in the walls of the house where you sleep? Yes___ No___

13. In the household where you live, what is the main source of water?

SEASONS

Rain Dry

Piped water:

____ ____ Piped into residence

____ ____ Public tap

Well water:

____ ____ Well in residence/yard/plot

____ ____ Private well outside plot

____ ____ Public well

Surface water:

____ ____ Spring

____ ____ River / stream

____ ____ Pond/lake

____ ____ Dam

Other sources:

____ ____ Rain water

____ ____ Tanker truck

____ ____ Bottled water

____ ____ Other: Specify:_____

14. How much time does it take to walk to source of water, fetch water, and come back?

SEASONS

Rain Dry

____ ____ None (piped in to household)

____ ____ Some, but less than an hour

____ ____ 1 to 2 hours

____ ____ 2 to 3 hours

____ ____ 3 to 4 hours

____ ____ More than 4 hours

15. Who fetches the water? (Several ticks may be made if it varies)

____ No one, not applicable

____ Children

____ Adult women

____ The person being interviewed

____ Adult men

____ Ox cart/donkey

____ Trucks or other vehicles

____ Others Specify _____

16. How is refuse disposed of in this household?

____ Pit, buried

____ Pit, open

____ Open field

____ Burned

____ Lake or river

____ Other Specify _____

17. What type of toilet facilities does the household have?

____ Water flush toilet

____ Pit latrine

____ None

____ Other Specify _____

18. What is the distance from the main residence where you live to health care facilities? (The number of hours of walking time for the respondent should be specified to nearest half hour).

Name	Hours (Walking)	
_____	_____	Which is the nearest antenatal clinic
_____	_____	Which antenatal clinic is actually used
_____	_____	Which is the nearest dispensary/health centre
_____	_____	Dispensary/health centre used most commonly
_____	_____	Which is the nearest hospital
_____	_____	Which is hospital used most commonly
_____	_____	Haydom Hospital

19. Is there access to transportation by car or bus from your main residence to the following health facilities?

Name	No	Sometimes	Steady	
_____	___	_____	____	Nearest antenatal clinic
_____	___	_____	____	Antenatal clinic actually used
_____	___	_____	____	Nearest health centre/dispensary
_____	___	_____	____	Dispensary/health centre used most
_____	___	_____	____	Nearest hospital
_____	___	_____	____	Hospital used most commonly
	___	_____	____	Haydom hospital

20. If there is access to any transport, what type of transport is available to the following facilities?

Hospital: Explain:_____

Dispensary/Health Centre: Explain:_____

Antenatal Clinic: Explain:_____

21. What type of transport is available to Haydom Hospital?

Specify:_____

MOTHER'S STATUS

(For all these questions, be extra polite and if interviewer thinks it may be necessary, ask more indirectly to get a correct answer.)

1. What is your marital status?

Yes No

___ ___ Are you presently married

___ ___ Are you presently divorced

___ ___ Are you presently widowed

___ ___ Are you presently single/unmarried

___ ___ Other: Specify: _____

2. If you are married, is your husband living in the same household as you? Yes____ No____

If NO, who do you get help from? Explain:_____

3. If you are not married, where do you get help from? Explain:_____

4. Have you been married several times? Yes____ No____

If YES, how many times have you been married including present marriage? __

5. How old were you the first time you married?_____

6. Does your husband have more than one wife? Yes____ No____

If YES, how many wives does he have, including you? _____

Which number of wife are you? _____

MOTHER'S HEALTH STATUS

7. What was your estimated age at menarche? _____ years

8. What was your age when you had your first pregnancy (time of conception)? _____ Years

(Here the interviewer may try to use certain events that are commonly known in order to get correct year)

9. Have you had any vaccinations when you were:

Yes No Don't know

___ ___ ___ A Child

___ ___ ___ Pregnant

10. Have you ever had any surgical operations? Yes__ No___ Don't remember___

If YES,which?

___ Abdomen

___ Gynaecological

___ Bones

___ Others; specify: _____

11. Have you ever had blood transfusions? Yes___ No___ Don't know___

12. Have you had any of the following diseases diagnosed at a health facility?

BEFORE (within 6 months before the beginning of this pregnancy); PRESENT (present pregnancy)

BEFORE			PRESENT			
Yes	No	Don't know	Yes	No	Don't know	
___	___	___	___	___	___	Diabetes
___	___	___	___	___	___	Thromboembolic disease (blood clots)
___	___	___	___	___	___	Hypertension (high blood pressure)
___	___	___	___	___	___	Heart disease
___	___	___	___	___	___	Epilepsy
___	___	___	___	___	___	Malaria
___	___	___	___	___	___	Relapsing fever(ticks)
___	___	___	___	___	___	Diarrhoea
___	___	___	___	___	___	Amoeba
___	___	___	___	___	___	Anaemia
___	___	___	___	___	___	Severe urinary tract infection
___	___	___	___	___	___	Gynaecological disease
___	___	___	___	___	___	Kidney disease
___	___	___	___	___	___	Lung disease(pneumonia etc)
___	___	___	___	___	___	Tuberculosis
___	___	___	___	___	___	Liver disease (jaundice)
___	___	___	___	___	___	Osteomyelitis (bone infection)
___	___	___	___	___	___	Severe skin infections
___	___	___	___	___	___	Sexually transmitted disease, (ex. Gonorrhoea, Syphilis, Trichomonas)
___	___	___	___	___	___	Others; specify: _____

13. Has your mother or any of your sisters had any of the following conditions during pregnancy, delivery or shortly after delivery?

Yes	No	Don't know		
___	___	___	Cramps or convulsions	If Yes, who: sister_____ mother____
___	___	___	High blood pressure	If Yes, who: sister_____ mother____
___	___	___	Swollen body	If Yes, who: sister_____ mother____
___	___	___	Albumin in urine	If Yes, who: sister_____ mother____

14. What would you have liked the MCH clinic from Haydom hospital to have assisted you with during this pregnancy? Specify: _____

USE OF STIMULANTS AND MEDICINE

(For these questions as well, be extra sensitive, and if interviewer finds it necessary, please use a more indirect approach)

1. Do you smoke tobacco? Yes:____ No:____

   If NO, have you smoked in the past? Yes:____ No:____

   If YES, at what age did you start smoking? Age:_____

2. For how many years have you smoked? Years:_____

3. Have you been smoking the last 30 days? Yes:____ No:____

   If YES, how many cigarettes do you smoke presently per day? Number:_____

4. If you smoke or sniff or chew any other type of tobacco presently other than cigarettes, please specify the type and amount per day. Specify: _____

5. Did you drink any of the following the last 30 days?

Yes	No	
____	____	Soda
____	____	Pombe(local brew)
____	____	Beer
____	____	Milk
____	____	Konyagi
____	____	Piwa (locally distilled alcohol)

6. What amount did you take of each of the following:

	Soda	Pombe	Beer	Milk	Konyagi	Piwa
Yesterday:	____	____	____	____	____	____
Total amount last 7 days:	____	____	____	____	____	____

7. Do you take any medicines on a regular basis presently? Yes:____ No:____

8. If YES, please specify the type and amount. Specify:_____

9. What kinds of traditional medicine did you use within the last 30 days?

   Specify:_____

10. Are you circumcized? Yes:____ No:____ Don't know:____

OBSTETRIC HISTORY

Previous pregnancies, first pregnancy no.1, second preg. no.2 and so on.

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
No. of preg-nancy	Year	Out-come -live -SB -abortion -ectopic -twins -other.....	Months of preg-nancy	Baby: -kg or -big -med. -small	Sex	Lactat-ing months	Place of delivery 1 home 2 dispensary 3 hospital 4 on the way 5 in a car 6 in field 7 other	Place planned delivery -home -dispensary -hospital -other	Who helped 1 alone 2 relative 3 midwife 4 TBA 5 doctor 6 other	Mode of delivery 1 spontan 2 vacuum 3 forceps 4 sectio 5 breech 6 other	Complicat-ions for mother: 1 APH 2 PPH 3 retained placenta 4 fever 5 obstructed labour 6 other	Child -live -dead	Cause of child's death	Age at death child	ANC -yes -no

8.2 QUESTIONNAIRE FOR VISIT AFTER DELIVERY

REPRODUCTIVE HEALTH PROJECT

1. All information is to be kept confidential by interviewer and anyone who is involved in the project.
2. If the respondent refuses to answer the questionnaire, please write this on the front page.
   If the respondent refuses to answer specific questions, please write an R in the right margin beside the specific question.

VISIT AFTER DELIVERY

These question should be answered by mother after delivery, usually after 2-3 months.

Is she willing to answer questionnaire: Yes:____ No:____

If not willing, please enter all information up till question 2.

Date of interview:_____

Name of interviewer:_____

Place of interview (MCH clinic):_____

MCH. Reg. No.:_____

1. Mother's name:_____ Clan:_____
2. Mother's address

   Ten-cell leader:_____

   Subvillage (Kitongoji):_____ Village:_____

   Ward:_____
3. Is the mother alive? Yes:____ No:____

   If NO, how many days after delivery did she die? _____
4. Child's name:_____ Sex: _____M/F

   2nd Twin:_____ Sex: _____M/F

   3rd triplet:_____ Sex: _____M/F
5. Date of birth:_____
6. Age today: Weeks:_____ (2nd Twin) Weeks:_____
7. Body weight today: Grams:_____ (2nd Twin) Grams:_____

PREGNANCY

8. What was the gestational age at this delivery? Weeks:_____

9. How many children were born of this pregnancy?_____

10. Did you have any problems in this pregnancy? specify: _____

11. Did you have problems with any of the following? (Several ticks may be made.)

Yes No

___ ___ Swelling of the body:
___ ___ Excessive tiredness:
___ ___ Malaria:
___ ___ Operation: (specify type)_____
___ ___ Fever:
___ ___ Excessive vomiting
___ ___ Diarrhoea
___ ___ Amoeba
___ ___ Weight loss
___ ___ Dizziness:
___ ___ Anaemia:
___ ___ Infections (specify):_____
___ ___ Other diseases (specify):_____
___ ___ Too heavy work load:
___ ___ Not enough food
___ ___ Depression:
___ ___ Social problems: (specify)_____
___ ___ Husband drinks excessive amount of pombe (local beer)
___ ___ Husband sells crops/livestock to get pombe
___ ___ Other problems (specify):_____

12. If you had problems, how did you get help? Explain:_____

DELIVERY

13. Place of delivery:(specify village):_____

____ Home

____ At relative's or friends house

____ Road side

____ In vehicle

____ Health centre/dispensary

____ Haydom Hospital

____ Other hospital

____ Other; specify:_____

Who assisted you: Name:_____

____ doctor

____ midwife

____ TBA

____ mother-in-law/mother

____ other; specify:_____

14. Where did you plan to deliver?

____ hospital

____ dispensary

____ home

____ other; specify:_____

15. If you did not deliver where you planned to, why?

____ Service too expensive

____ Not accepted by family; Why?_____

____ Not enough time after birth started

____ Transport not available

____ Other; specify:_____

16. Child's bodyweight/size/height when born (2 T. = 2nd twin)

Bodyweight Grams:_____ (2 T. Grams:_____)

Size: Big:_____ (2 T. Big:_____)

Medium:_____ (2 T. Medium:_____)

Small:_____ (2 T. Small:_____)

Height: cm: _____ (2 T. cm:_____)

17. Was it difficult to get the baby out?

Yes:___ No:___ (2 T. Yes:___ No:___)

If YES, Why?

____ very big baby (2 T. _____)

____ mother's pelvis was narrow (2 T. _____)

____ other; (2 T. _____) specify:_____

18. What was the presenting part?

____ Head (2 T. _____ head)

____ Breech (2 T. _____ breech)

____ Other (2 T. _____ other) specify:_____

19. Did the baby cry within one minute after delivery?

Yes:___ No:___ (2 T. Yes:___ No:___)

20. What was the umbilical cord cut with?

____ new razor blade

____ used razor blade

____ knife

____ arrow (special for bleeding cows)

____ peeling of sugar cane

____ hospital equipment

____ other; specify:_____

21. After cutting the umbilical cord, what did you put on the cord?

____ thread

____ medicine

____ nothing

____ tendon thread

____ hospital equipment

____ other; specify:_____

22. Was the baby able to suck mothers milk just after birth?

Yes:___ No:___ Didn't get chance:___ (2 T. Yes:___ No:___ Didn't get chance:____)

If NO, or Didn't get chance, Why?:_____

23. In the first week the baby got: (Several ticks possible)

Yes	No			Yes	No	
___	___	Mother's milk	(2 T.)	___	___	
___	___	Cow's milk	(2 T.)	___	___	
___	___	water	(2 T.)	___	___	
___	___	porridge	(2 T.)	___	___	
___	___	other;	(2 T.)	___	___	specify:_____

24. Within the first month (30 days), the baby had:

Yes	No			Yes	No	
___	___	Fever	(2 T.)	___	___	If YES; Explain:_____
___	___	Diarrhoea	(2 T.)	___	___	If YES; Explain:_____
___	___	Cough	(2 T.)	___	___	If YES; Explain:_____
___	___	Wasted	(2 T.)	___	___	If YES; Explain:_____
___	___	Accident	(2 T.)	___	___	If YES; Explain:_____

25. When your child was ill where, how was he/she helped?

Explain:_____

26. Is the child in good health now? Yes:___ No:___

If NO, explain:_____

MOTHER'S PROBLEMS WITH DELIVERY AND 6 WEEKS THEREAFTER

27. Was there bleeding before delivery (APH)?: Yes:___ No:___

If YES, what type of help did you get? Explain:_____

28. Was there excessive bleeding after delivery (PPH)?: Yes:___ No:___

If YES, what type of help did you get? Explain:_____

29. When did the placenta come out?

____ within an hour after the child

____ more than one hour after the child

30. Did you get fever after the delivery? Yes:___ No:___

If YES, when did it occur after delivery: Day:_____

What was the fever like? Several ticks may be made.

____ very high

____ average

____ low

____ intermittent

____ continuous

What did you do to get better? Explain:_____

31. Have you had cramps or convulsions?

____ no

____ yes, before delivery

____ yes, during delivery

____ yes, after delivery

32. Did you get any problem after delivery? Yes:___ No:___

If YES, explain:_____

33. Have you had problems controlling any of the following due to previous deliveries:

Stool? Yes:____ No:____

Urine? Yes:____ No:____

What kind of help did you get? Explain:_____

34. Are you in good health now? Yes:___ No:___

If NO, specify the problem:_____

35. If you had problems during delivery and up till 6 weeks after delivery, how did you get help?

Explain:_____

FAMILY PLANNING

1. As you may know, there are various ways that a couple can delay the next pregnancy or avoid pregnancy. Do you know of any of these methods?

   Yes:___ if yes, go to 2

   No: ___ if no, go to 3

2. a) Which methods do you know of? _____

   Do you know any others? _____

   Yes No

   ___ ___ b) Have you ever used that (those) method(s)?

3. One way a woman can delay the next pregnancy, or avoid getting pregnant, is to take a PILL every day.

   Yes No

   ___ ___ a) Have you ever heard of this method?

   ___ ___ b) Have you ever used this method?

4. A woman may have an INJECTION every three months to avoid pregnancy.

   Yes No

   ___ ___ a) Have you ever heard of this method?

   ___ ___ b) Have you ever used this method?

5. A woman may have a LOOP or A COIL of PLASTIC or METAL, THE INTRAUTERINE DEVICE, inserted in her womb by a doctor and left there.

   Yes No

   ___ ___ a) Have you ever heard of this method?

   ___ ___ b) Have you ever used this method?

6. She may also place a DIAPHRAGM or TAMPON or SPONGE in herself, or use FOAM TABLETS or JELLY or CREAM.

   Yes No

   ___ ___ a) Have you ever heard of these methods?

   ___ ___ b) Have you ever used any of them?

7. Some women wash themselves immediately after sex, with WATER or some other liquid.

Yes No

___ ___ a) Have you ever heard of this method?

___ ___ b) Have you ever used this method?

8. There are also some methods men use so that their wives will not get pregnant. Some men wear a CONDOM during sex.

Yes No

___ ___ a) Have you ever heard of this method?

___ ___ b) Have you and your husband ever used it?

9. Some couples avoid having sex on particular days of the month when the woman is most able to become pregnant. This is called the SAFE PERIOD or RYTHM METHOD.

Yes No

___ ___ a) Have you ever heard of this method?

___ ___ b) Did you and your husband ever do this?

10. Some men practice WITHDRAWAL, that is, they are careful and pull out before climax.

Yes No

___ ___ a) Have you ever heard of this method?

___ ___ b) Did you and your husband ever use this method?

11. Another way of avoiding getting pregnant is to GO WITHOUT SEX for several months or longer.

Yes No

___ ___ a) Have you ever heard of this method?

___ ___ b) Have you ever done this to avoid getting pregnant?

12. Some women have an operation, called STERILIZATION, having their tubes tied, in order not to have any more children.

Yes No

___ ___ a) Have you ever heard of this method?

___ ___ b) Have you had a sterilization?

13. Some men have a sterilization operation, called VASECTOMY, so that wives will not have more children.

Yes No

___ ___ a) Have you ever heard of this method?

___ ___ b) Has your husband had vasectomy?

14. Have you ever heard of any other method which women or men use to avoid pregnancy?
Specify:_____

Yes No

___ ___ a) Have you and your husband ever used this method?

15. I want to make sure I have the correct information. Have you ever done anything or tried to delay or avoid getting pregnant?

Yes No

___ ___ Specify:_____

16. Do you wish to have more children?

Yes No

___ ___

17. If yes, how many more do you wish to have?
Total:____ Boys:___ Girls:___ Don't know:___

18. Do you and your husband agree on this matter?
Yes:___ No:___ Haven't discussed it:___

19. If you don't agree, in what way do you not agree?
Specify:_____

8.3 QUESTIONNAIRE FOR VERBAL AUTOPSY FOR INFANTS

CONFIDENTIAL

VERBAL AUTOPSI FOR INFANTS

INTERVIEW

1. Interviewer: _____
2. Respondent: _____
3. Respondents Relation to the child:_____
4. Date of interview:_____

PERSONALIA

5. Child's names :_____
6. Sex(M/F):__
7. Liveborn(Y/N):___
8. Ethnic group:_____
9. Religion:_____
10. Mother's names:_____ Age:___ Living(Y/N):__
11. Father's names:_____ Age:___ Living(Y/N):__

ADDRESS

12. Ten Cell Leader (Balozi):_____
13. Kitongoji:_____
14. Kijiji:_____
15. Kata:_____

CHRONOLOGY

16. Date of birth:_____ Exact:__ Guessed:__
17. Date of onset of sickness:_____
18. Date of death:_____
19. If mother died, mother's date of death:_____

CIRCUMSTANCES OF DEATH

20. Was the child seen during the last illness by:
    __ village health worker?
    __ trained nurse?
    __ doctor?
    __ traditional healer?
    __ other,specify:_____

21. Was the child admitted to hospital during the final illness? Y/N___

22. Where did death occur?
    __ home
    __ dispensary/health centre
    __ hospital
    __ other,specify:_____

RESPONDENT'S ACCOUNT OF DEATH

23. What does the respondent consider as cause of death, and how did it occur?

    _____

    _____

OBSTETRIC HISTORY

24. Fill in obstetric history for child's mother on the last page.
25. How many other deliveries has she had before? ___
26. How many children to the mother are now alive? ___
27. What is the age of the last child (months)? ___
28. How many tetanus toxoid did she receive this pregnancy? ___
29. How many TT did she receive in other pregnancies? ___

INDEX PREGNANCY

30. Did the mother attend ANC this pregnancy? Y/N __
    If YES, -do you have the card? Y/N
    -where did she attend? _____
    -how many times?___
    -did she attend for problem or routine? P/R __
    -did she receive any treatment? Y/N __
    -did she have risk factors noted on the card? Y/N __
    -was she referred? Y/N __
    If YES, to where/who:_____

31. Did she have any problems in this pregnancy? Y/N:__

Please specify: _____

Did she have problems with any of the following during pregnancy?

Yes No

___ Don't know

___ ___ Swelling of the body

___ ___ Excessive tiredness

___ ___ Malaria

___ ___ Operation: (specify type)_____

___ ___ Fever

___ ___ Excessive vomiting

___ ___ Diarrhoea

___ ___ Amoeba

___ ___ Weight loss

___ ___ Dizziness:

___ ___ Anaemia:

___ ___ Infections (specify):_____

___ ___ Other diseases (specify):_____

___ ___ Too heavy work load

___ ___ Not enough food

___ ___ Depression

___ ___ Social problems: (specify)_____

___ ___ Husband drinks excessive amount of pombe (local beer)

___ ___ Husband sells crops/livestock to get pombe

___ ___ Other problems (specify):_____

32. How did she get help?(where, what kind of help, did she get better)

Explain:_____

DELIVERY

33. Was the baby delivered before death?__

34. What was the gestational age? Weeks:_____ Don't know:____

35. How many children were born of this pregnancy? ___ Don't know:___

If TWINS,

-name of other twin:_____

-is other twin alive? Y/N:__

-who came first?_____

36. Place of delivery:(specify village):_____

____ Home

____ At relative's or friends house

____ On the road side: Explain:

____ In vehicle: Explain:

____ In ambulance: Explain:

____ Health centre/dispensary

____ Haydom Hospital

____ Other hospital

____ Other; specify:_____

____ Don't know

37. Who assisted the delivery: Name:_____

____ doctor

____ midwife

____ TBA

____ mother-in-law/mother

____ other; specify:_____

____ don't know

38. Where did she plan to deliver?

____ hospital

____ dispensary

____ home

____ other; specify:_____

IF she did not deliver where she planned to, why?

____ Service too expensive

____ Not accepted by family; Why?_____

____ Not enough time after birth started

____ Transport not available

____ Other; specify:_____

39. For how long was she in labour? __ hrs

40. Mode of delivery:

___ Normal

___ Vacuum

___ Forceps

___ Breech

___ Cesarian Section

___ Other:_____

41. Was it difficult to get the baby out?

No: ___ (twin No: ___)

Yes:___ (twin Yes:___)

If YES, why? __ very big baby

__ mother's pelvis was narrow

__ other;specify:_____

42. What was the presenting part?

____ Head (twin: ____ head)

____ Breech (twin: ____ breech)

____ Other (twin: ____ other), specify:_____

43. What was the cord cut with?

____ new razor blade

____ used razor blade

____ knife

____ arrow(tsaxara/shæwuda)

____ peeling of sugar cane

____ hospital equipment

____ other; specify:_____

____ don't know

44. After cutting the cord, what was applied:

____ string

____ medicine

____ nothing

____ tendon thread

____ hospital equipment

____ other; specify:_____

____ don't know

45. What was applied on the cord during the first week of life?

__ string

__ medicine

__ nothing

__ oil

__ tendon (taami, fuwenda)

__ don't know

__ other,specify:_____

CHILD

46. Child's bodyweight/size/height **when born**

Bodyweight: Grams :_____ (twin Grams : _____)

Size: Big :____ (twin Big : ____)

Small :____ (twin Medium: ____)

Medium:____ (twin Small : ____)

Height: cm:_____ (twin cm: _____)

47. Did the baby cry within one minute after delivery? Y/N/U __

48. Was the baby able to suck mothers milk just after birth?

Yes:__ (twin Yes:___)

No:___ (twin No: ___)

Didn't get chance:___ (twin Didn't get chance:____)

Don't know:___ (twin Don't know:___)

If No, or Didn't get chance, Why?:_____

49. Did the infant stop sucking milk when he/she became ill? Y/N:__ (twin: Y/N:__)

50. In the first week (7 days) the baby got:

Yes	No		Yes	No
___	___	Mother's milk	(twin ___	___)
___	___	Cow's milk	(twin ___	___)
___	___	water	(twin ___	___)
___	___	porridge	(twin ___	___)
___	___	other;	(twin ___	___) specify:_____
___		don't know	(twin ___	)

51. Had the child been weaned before he/she became ill? Y/N:__

If YES, how many months before death occurred? ___

52. Within the first month (30 days), the baby had:

Yes	No		(twin Yes	No)	
___	___	Fever	(twin ___	___)	If YES, Explain:_____
___	___	Diarrhoea	(twin ___	___)	If YES, Explain:_____
___	___	Cough	(twin ___	___)	If YES, Explain:_____
___	___	Wasted	(twin ___	___)	If YES, Explain:_____
___	___	Accident	(twin ___	___)	If YES, Explain:_____
___		Don't know	(twin ___	)	

53. How many days/weeks passed after birth before the infant became ill?_____

54. How did she get help when the child was ill? (Where, what kind of help, did it help?)

_____

SYMPTOMS PRECEDING INFANT'S DEATH

Did the child have any of the following features during his/her last illness? If yes, indicate for how many days it lasted.

55. Fever..... Y/N:__ Days:____

56. Diarrhoea and/or vomiting..... Y/N:__ Days:____

57. Cough and/or rapid respiration.... Y/N:__ Days:____

58. Stiff neck..... Y/N:__ Days:____

59. Fits (convulsions)..... Y/N:__ Days:____

60. Rash..... Y/N:__ Days:____

61. Loss of weigh..... Y/N:__ Days:____

62. Drowsy or unconscious..... Y/N:__ Days:____

If you obtain a positive answer to one or more of the above questions ask following questions (only ask about those features for which positive answers were obtained above).

FEVER

63. Was the fever __ very severe
__ moderate
__ mild

64. Was the fever __ present all the time
__ intermittent

65. Was the fever the only feature of the illness? Y/N:__

DIARRHOEA AND/OR VOMITING

66. Did the child have sunken eyes? Y/N:__

67. Did the child have diarrhoea? Y/N:__

If YES,

-was diarrhoea __ present throughout illness
__ intermittent

-was diarrhoea __ very severe
__ moderate
__ mild

-when the diarrhoea was worst,how often did the child pass stool?
__ <5 times per day
__ 5-9 times per day

__ 10 or more times a day

-when the diarrhoea was worst was the stool:

__ watery

__ soft

__ normal consistency

68. Did the stool ever contain blood? Y/N:__

69. Did the child have abdominal pain/colic? Y/N:__

70. Did the child have vomiting? Y/N:__

If yes:

-was the vomiting __ present throughout illness

__ intermittent

-was the vomiting __ very severe

__ moderate

__ mild

-when the vomiting was worst, how often did the child vomit?

__ less than 5 times per day

__ 5-9 times per day

__ 10 times or more per day

COUGH AND/OR RAPID RESPIRATION

71. Did the child have indrawings of the chest? Y/N:__

72. Did the child have wheezing? Y/N:__

73. Did the child have grunting respiration? Y/N:__

74. Was the child using alae nasi/playing nostrils? Y/N:__

75. Did the child have cough? Y/N:__

If YES:

-was cough __ very severe

__ moderate

__ mild

-did the child cough up any sputum? Y/N:__

-did the child cough up any blood?Y/N:__

76. Did the child have rapid breathing? Y/N:__

If YES,

-was breathing __ very rapid?

__ moderately rapid?

STIFF NECK

77. Could the mother/guardian bend the neck of the child? Y/N:__

78. Does the mother/guardian think the child had meningitis? Y/N:__

FITS OR CONVULSIONS

79. How many fits did the child have?

__ <5

__ 5-9

__ 10 or more

80. Were the fits __ small twitching?

__ major movements?

81. Did the fits involve:

__ face

__ neck

__ arms

__ legs

82. Between fits was the child:

__ fully awake

__ drowsy

__ unconscious

RASH

83. Was the rash present on the

__ face

__ neck

__ arms

__ palms

__ legs

84. What were the features of the rash?

__ flat patches

__ bumps

__ bumps with fluid

__ bumps with pus

__ other,describe:_____

85. Did the child have sore red eyes? Y/N:__

LOSS OF WEIGHT

86. Was the child thinner than he/she should have been: Y/N:__

If YES, was the child thinner:

__ just during the final illness

__ since birth

__ since weaning

__ other, explain:_____

87. Was the child shorter than he should have been? Y/N:__

If YES,

-had the child been smaller than usual since birth? Y/N:__

88. Did the child have normal appetite? Y/N:__

89. Did the child have swelling of the feet? Y/N:__

90. Did the child have flaky skin? Y/N:__

DROWSY OR UNCONSCIOUS

91. Was the child __ fully awake?

__ drowsy?

__ unconscious?

FAMILY HISTORY

92. Were any other children in the compound seriously ill at the time that the child died? Y/N:__

If YES, describe what kind of illness they had:_____

93. Had any other children in the compound recently had **measles**?

RECORDS, HEALTH CARD

94. Can the child's health card be found? Y/N:__

If NO, why? _____

Is Health card copied? Y/N:__

95. Are there any hospital records of child's illness? Y/N:__

Are hospital records copied? Y/N:__

GENERAL COMMENTS _____

PROBABLE CAUSES OF DEATH

1.Main cause of death:_____

2.Contributing:_____

3.Contributing:_____

4.Contributing:_____

5.Contributing:_____

OBSTETRIC HISTORY

Previous pregnancies, first pregnancy no.1, second preg. no.2 and so on.

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
No. of preg-nancy	Year	Out-come: -live -SB -abortion -ectopic -twins -other	Months of preg-nancy	Baby: -kg or -big -med. -small	Sex	Lactat-ing months	Place of delivery 1 home 2 dispensary 3 hospital 4 on the way 5 in a car 6 in field 7 other	Place planned delivery -home -dispensary -hospital -other	Who helped 1 alone 2 relative 3 midwife 4 TBA 5 doctor 6 other	Mode of del. 1 spontan 2 vacuum 3 forceps 4 sectio 5 breech 6 other	Complicat-ions mother: 1 APH 2 PPH 3 retained placenta 4 fever 5 obstructed labour 6 other	Child -live -dead	Cause of death child	Age at death child	ANC -yes -no

8.4 RESEARCH PERMITS

NEM

DEN NASJONALE FORSKNINGSETISKE KOMITE FOR MEDISIN
Norges forskningsråd (NFR), avdeling NAVF

Gaustadalléen 21
0371 Oslo 3
Tel 22 95 87 84
Fax 22 69 84 71

Bergen 3.10.94

Svend Gudmund Hinderaker
Senter for internasjonal helse
Armauer Hansen Building
5021 Bergen

Prosjekt: BARNE- OG MØDREDØDELIGHET PÅ LANDSBYGDA I TANZANIA

Det vises til din søknad av 5.08.94 til NEM samt brev av 20.09.94 fra Gunnar Kvåle til NEM angående samme sak. Søknaden ble behandlet på NEMs møte 26.09. d.å. NEM har ingen kommentarer til prosjektet og tilrår at det gjennomføres. NEM finner det ønskelig å få tilsendt en sluttrapport når prosjektet er blitt gjennomført.

Med hilsen

Jan Helge Solbakk

Jan Helge Solbakk,
sekretariatsleder

TANZANIA COMMISSION FOR SCIENCE AND TECHNOLOGY

RESEARCH PERMIT

No: 94-118 NA Issued: 14 June 1994

1. Name: Dr. Sven Gudmund Hinderaker

   from: Norway

   is hereby authorized to conduct research in Tanzania entitled as shown in 2 below.

2. Title: Perinatal and Infant Mortality and its Determinants in rural Tanzania.

3. Research shall be confined to the following regions:

   Arusha region.

4. This permit is valid within the following dates: from 14 June1994 to: 13June 1995

5. Local contact/collaborator: Coordinator , MUTAN, KCMC, Moshi.

J.K. LIGUNDA(Mrs)
for: DIRECTOR GENERAL

P.O. Box 4302 Dar es Salaam, Tanzania.
Telephone [052] 75311, 75312, 75314, 75315
Fax [052] 75313
Email dg@costech.wn.apc.org

TANZANIA COMMISSION FOR SCIENCE AND TECHNOLOGY

Telegrams: COSTECH
Phone: 255 51 75311, 75312,
Director General's direct line: 74427
Fax: 255 51 75313
Telex : 41651 DEPLAN
E-M: costech@costech.gn.apc.org

Ali Hassan Mwinyi Road
P.O. Box 4302
Dar es Salaam
Tanzania

In reply please quote:

Ref. No: Dr CST/RCA 94/23

14 June 1994

Director of Immigration Services
Ministry of Home Affairs
P.O. Box 512
Dar es Salaam

Dear Sir/Madam

RE: RESEARCH PERMIT

We wish to introduce to you Dr. Sven Gudmund Hinderaker from Norway

who has been granted research permit no. 94-118 NA dated 14 June1994

The permit allows him/her to do research in the country entitled:

Perinatal and Infant Mortality and its Determinants in rural Tanzania.

Co-researchers, if any, are listed below.

We would like to support the application of the researcher(s) for the appropriate immigration status to enable the scholar(s) begin research as soon as possible.

By copy of this letter, we are requesting regional authorities and other relevant institutions to accord the researcher(s) all the necessary assistance. Similarly the designated local contact is requested to assist the researcher(s).

Yours faithfully

J.K.Ligunda(Mrs)
for: DIRECTOR GENERAL

cc: 1. Regional Development Director(s) Arusha region.
2. Local Contact
3. Other Institutions

Co-researchers

9 Research papers I-IV

Paper I: Perinatal mortality in rural Tanzania

Reproduced with the permission of Journal of Health, Population and Nutrition.

Paper II: Avoidable stillbirths and neonatal deaths in rural Tanzania

Reproduced with the permission of BJOG: An International Journal of Obstetrics and Gynaecology.

Paper III: Anemia in pregnancy in the highlands of Tanzania

Reproduced with the permission of Acta Obstetricia et Gynecologica Scandinavica.

Paper IV: Anemia in pregnancy in rural Tanzania: Associations with micronutrients status and infections

Reproduced with the permission of European Journal of Clinical Nutrition.